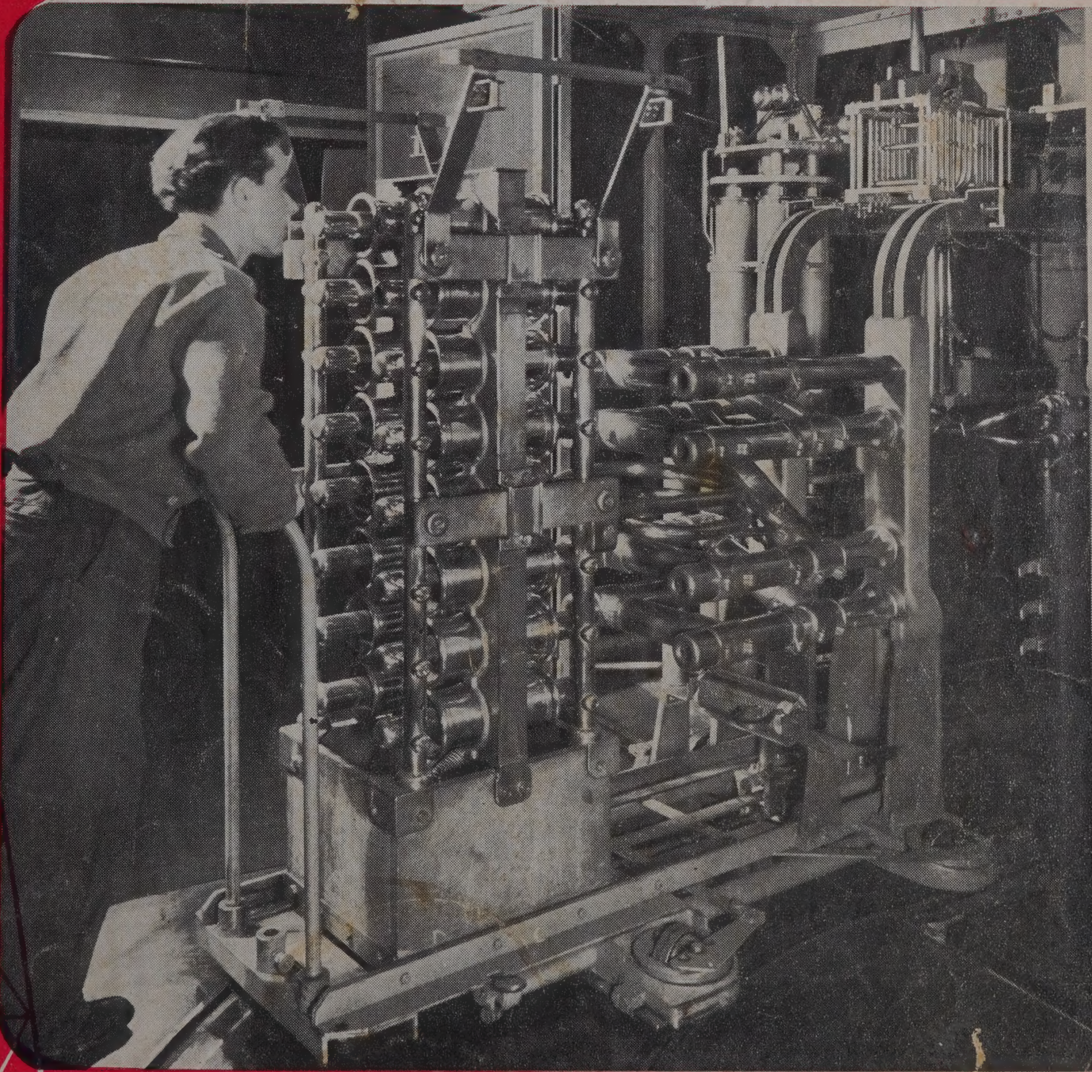
RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND



OCTOBER 1, 1948 VOL. 3, NO. 7 1/10

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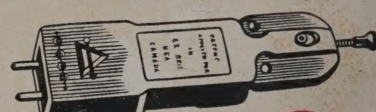

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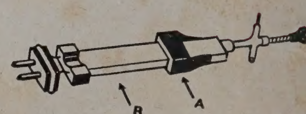

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RADIO and ELECTRONICS

Vol. 3, No. 7 — 1st October, 1948

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OUR COVER

This month's picture is a striking example of the difference between transmitting and receiving component parts. The truck is a high-powered transmitter's amplifier tank circuit, ready to be wheeled into its operating position. The vacuum-type fixed tuning condensers can be seen in the foreground, and a glimpse can be got of the water-cooled tuning coil. This picture was taken at the new B.B.C. shortwave transmitter at Skelton, which was designed and built by the English Electric Company, Limited.

AN APOLOGY

We regret that, through circumstances outside our control, it is not possible to publish this month the October predictions for the 10 and 20-metre amateur bands. The world charts from which our own tables are computed, and which we normally receive sufficiently in advance to enable up-to-date predictions to be issued, have not come to hand as we go to press.

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The Cathode Ray Tube as an Aid in Electronic Work

A very pleasant situation now exists for amateur and professional workers with electronic circuits in that some thousands of three and five inch cathode ray tubes have been released for public purchase, at what can only be described as token prices, from stocks that were built up during the war to supply the needs of the armed services and the development laboratories. Already, large numbers of these tubes have been disposed of, and it is safe to assume that many more will be sold in the not-too-distant future.

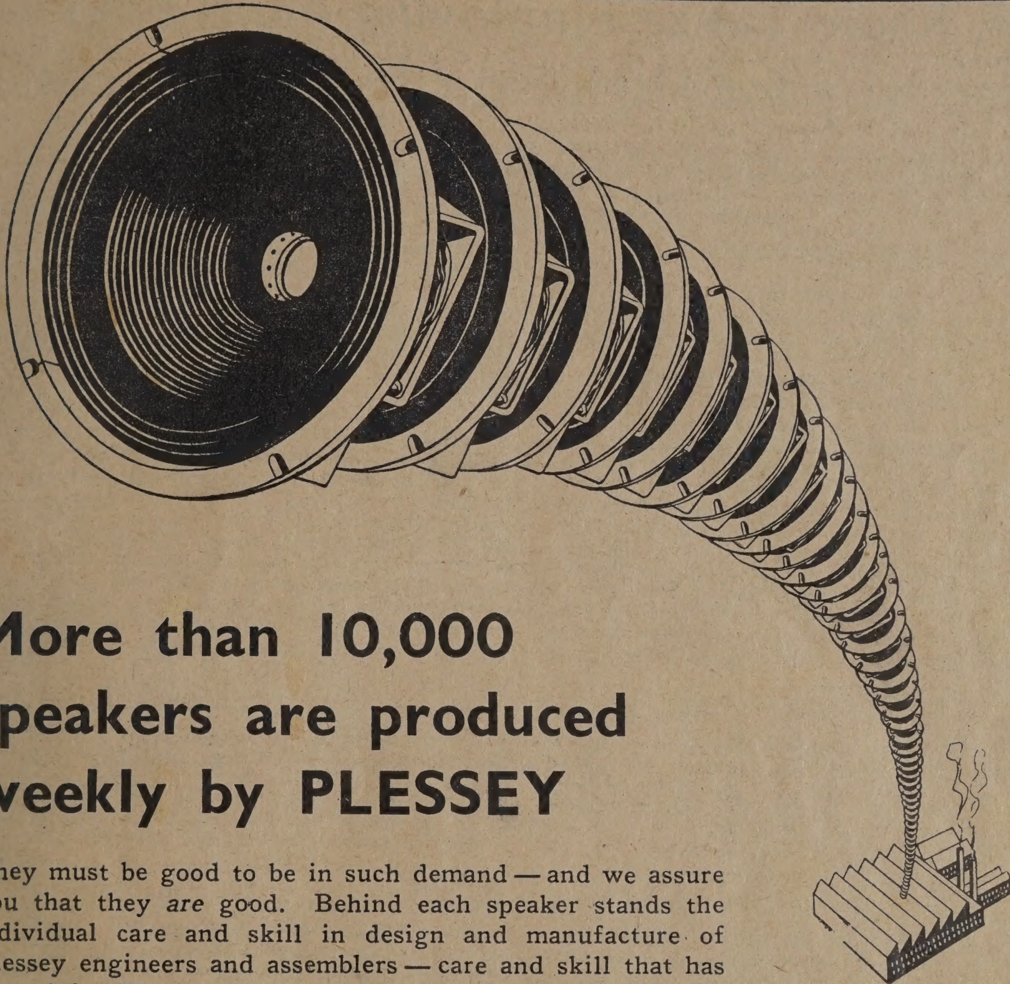
It also seems safe to guess that numbers of the tubes bought have been acquired by people whose idea has been to get in while the going was good, and who have no immediate plans for putting them to work, pending, perhaps the financing of the necessary auxiliary equipment. The latter, when the tubes themselves have been bought at less than the retail price of many receiving valves, represents by far the greatest outlay in building a complete oscilloscope, and many people seem to be under the impression that to make satisfactory use of a cathode ray tube, it is essential to have a comparatively complicated system of amplifiers and a linear time-base. It is our purpose here to point out that such is by no means the case, and to illustrate in a general way how use can be made of the C.R.T. and its high-voltage supply for a number of purposes.

Suppose, then, that we have our tube, and have constructed a power supply which makes it a working unit, complete with brilliance, focus, and shift controls. Few books give circuits that do just this much and no more, so that the fact is implied to the uninitiated that such a simple set-up is of no practical value. However, this is far from being true. For instance, trapezoidal modulation patterns do not need either amplifiers or a time-base. This is well known to amateur transmitters. Again, nothing more is needed in order to use the 'scope for an output voltage indicator. This use covers such things as taking frequency response curves, and measuring the gain of audio amplifier stages. A much less widely known fact is that the bare tube itself can be used in estimating, and even for measuring, the distortion produced by an amplifier. This last does not involve the use of any amplifiers other than the one under test, and does not even need an audio oscillator of pure wave-form. It can be used for making frequency comparisons, and for measuring power output, at both audio and radio frequencies. It can also be used for measuring the degree of phase-shift in amplifiers, and for measuring the sizes of resistors and condensers!

All these applications, we repeat, require no equipment other than those articles which would have to be used in any case, whether or not the cathode ray tube were used as the indicator. The list is by no means complete, either, and other uses, such as the neutralizing of transmitting amplifiers and the adjustment of transmitting circuits generally can easily be imagined. The fact is, that unless one has such an instrument on the bench, ready for use at any time, it is impossible to visualize how indispensable it can become.

In the space allotted to an Editorial it is not possible for us to do more than we have done, namely, to give indications that can be followed up by those who may be sufficiently interested; from time to time, certain of the above applications will no doubt find their way into these pages. The difficulty here is rather one of seeing that the whole of *Radio and Electronics* does not become filled with information on oscilloscopes and their use, because it would be quite easy for this to happen!

At any rate, to show that we ourselves believe in the statements that have been made in this Editorial, we are publishing, in our next issue, the circuit and description of a cathode ray tube unit comprising the tube itself, its power supply, and all control circuits, including shift controls for both axes. This unit is for the 5BP1/5GP1 tube or any of its equivalents, and in fact could be employed for any American 5 in. or English 6 in. tube, with only slight modification, if any. Following on this article, we have prepared a separate unit, comprising a linear time-base, and identical amplifiers for the X and Y axes. This unit, in conjunction with the basic tube unit, gives the utmost in flexibility, as well as in range of application, for with these units it is possible to do many things that cannot be done at all with a 'scope whose amplifiers are permanently connected to the tube. Any combination of direct connection and amplifier, for different axes, or of balanced and unbalanced input to either the tube itself or to the amplifiers is catered for. At the same time, the amplifier and time-base unit is of very straightforward design, and presents much less difficulty to the constructor than does the "5-inch Service Oscilloscope" which proved so popular shortly after our maiden issue. The only real virtue lost is that of compactness, but this may readily be dispensed with in favour of the vastly superior flexibility of operation that the two-unit system affords.



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A Radio Tuner employing Multi-Point Selectivity for High-Fidelity Reproduction

This tuner, while a little more elaborate than others which we have published recently, has advantages not possessed by our previous designs. It can be used equally well for high-fidelity local reception, or for distant reception, since its selectivity is high, and any number of selectivity points may be provided.

INTRODUCTORY

A month or two ago there was published in these pages an article entitled "An Idea for a High-Fidelity Tuner," in which the whole subject of high-quality local reception was reviewed and in which the scheme of using a high intermediate frequency in order to achieve greater bandwidth was treated in detail. In that article we mentioned the possibility of using a normal intermediate frequency, and an I.F. amplifier in which the selectivity could be varied over wide limits, either continuously or in steps.

This is the system that is almost universally used in high-priced receivers that are labelled "high-fidelity" by their manufacturers. However, in these receivers one rarely finds the continuously variable system used, and when steps are provided it is equally rare to find more than two selectivity positions. In spite of this, it is considered to be the best compromise between the conflicting requirements of good audio quality on the one hand, and high sensitivity on the other. The idea of using a separate tuner for high-quality local reception, while admirable for those who are not concerned about having a standard sort of receiver, naturally has little appeal to manufacturers, who must use as few valves as possible, and who cannot afford to have a number of valves idling when the set is being used for one type of reception. Also, there are many people who, while they would certainly like to have the advantages conferred by a separate local tuner, are not disposed to forgo the usual features of high sensitivity and narrow bandwidth or to put up with a set that is at all peculiar in possessing two separate tuning dials and even separate volume controls.

It is for people such as this that the present tuner has been designed. It is capable of being added to a good audio amplifier, either as an integral part of a complete receiver or as a separate unit, forming, with the audio section, a receiver possessing all the features to which listeners have become accustomed and, in addition, giving a quality of reproduction from local radio stations comparable with that from the direct playing of good gramophone records with a high-quality pick-up.

THE SYSTEM USED

The tuner follows conventional practice in consisting basically of an oscillator-mixer, a stage of I.F. amplification, a diode second detector, and a further diode for A.V.C. rectification. The intermediate frequency is 465 kc/sec., and is unusual only in that a special coupling system is used between the mixer plate and the I.F. stage grid. Apart from this, and the use of a cathode follower output stage whose function is to feed the audio amplifier from a low-impedance source, thereby obviating the necessity of using a high-quality plate-to-line transformer, there is nothing alarmingly new about the design, and nothing which need present any difficulty to the would-be constructor.

The method of obtaining the extra bandwidth for the intermediate and high-fidelity positions of the selectivity switch is basically that of increasing the coupling between the two windings of a double-tuned transformer, although the method of doing so is rather novel, as the coupling is not mutual inductive, as is usually the case, but employs the system commonly known as **bottom capacity coupling.** This has several important advantages over varying the inductive coupling between windings, and, although the final circuit diagram looks rather complicated, the principle is easily grasped, so that slight modifications to suit individual requirements can readily be made. Before going on to describe the actual construction of the tuner, it will be as well to describe the action of the variable selectivity circuit in detail. While the circuit is rather more advanced than many we have recommended for amateur constructors, there is no need for intending builders to "take fright," for **one of the chief virtues is that it does not require unusual test equipment for proper alignment, nor has it any critical adjustments whatever. In fact, once built, it is as easy to align as the simplest I.F. amplifier.**

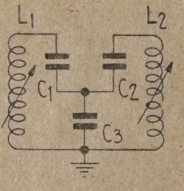

Fig. 1

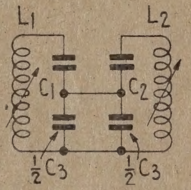

Fig. 2

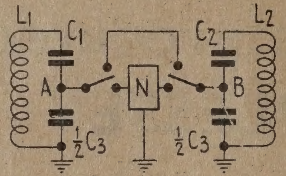

Fig. 3

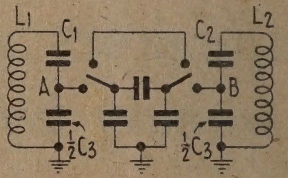

Fig. 4

Note.—The switch connection in Fig. 4 should be as for Fig. 3, not as drawn.

DETAILED DESCRIPTION OF THE VARIABLE SELECTIVITY SYSTEM USED IN THE TUNER

It is well known that one way to achieve an extended frequency response in a superheterodyne receiver is to increase the coupling between the windings of the I.F. transformers. When this is done, the response curve of the I.F. amplifier, instead of showing a sharp peak at the centre frequency of 465 kc/sec., and a rapid falling-off in response at fre-

quencies quite close to resonance, exhibits two peaks, more or less widely spaced, with a small valley in between. In this way, the response can be made substantially constant for frequencies extending for some distance on either side of the centre frequency, to which the individual windings of the transformer are tuned. This arrangement works very well, within limits, and is sometimes employed in receivers which do not feature variable selectivity in order to increase the high-frequency response of the whole set. When we say that it works well "within limits," what is meant is this: If the coupling in the I.F. transformers is made too tight, the two peaks move farther apart, but the valley between them becomes too deep. The result is that the set now loses a good deal of sensitivity, and, what is more important, acquires a sharply-rising characteristic in the higher audio frequencies. This is not a desirable state of affairs at all, but at present we can forget about it, for we know that means are available for compensating for it. The main difficulty in putting such a scheme into operation is one that has not yet been mentioned. It is this: When the extra coupling is brought into action, the widening of the response must take place evenly on either side of the centre frequency. Unless this happens, the set will need retuning each time the selectivity is broadened. This is clearly impracticable, for, apart from the inconvenience caused to the operator, it brings up the difficult problem of correctly tuning a set which has a wide response in the I.F. amplifier. Many people find it difficult enough to properly tune a set which has the usual sharply-peaked I.F. response, let alone doing so when the station appears to occupy several degrees of the dial owing to the increased bandwidth! Thus, any system which intends to widen the pass-band of the receiver must be capable of being tuned accurately with the selectivity in the "normal" position, and thereafter of widening the response symmetrically about the point to which the system peaks in the "normal" position.

Unfortunately, there is only one theoretically simple way of widening the pass-band in this manner. It is by using I.F. transformers in which the spacing of the windings can be mechanically varied in order to vary the coupling between them. This does produce symmetrical expansion of the I.F. bandwidth about the centre frequency, in this case 465 kc/sec. Again, unfortunately, such I.F. transformers are difficult and expensive to design and manufacture. They may be purchased, like many other desirable things, in the U.S.A., but not here, so that this method, which is easily the simplest from the electrical point of view, is "out." However, there is another way of achieving the same result, at the expense only of having to put up with switched selectivity positions instead of continuous variation.

This method was first propounded by Mr. Varrall in the British publication "Wireless World" and does not appear to have received the amount of attention it deserves from set designers. It contains no great difficulty and has some advantages not possessed by any other scheme that has been put forward. The basic circuit is shown in Fig. 1. The two coils, L_1 and L_2, are similar to those of any 465 kc/sec. I.F. transformer, both in inductance and construction. L_1 can be considered as the inductance in the plate of the mixer stage, and L_2 as that in the grid of the I.F. amplifier. In Fig. 1 no account has been taken of the D.C. voltages occurring in the circuit, in order to make the signal circuit clearer. The practical modifications required will be detailed later. The condensers, C_1, C_2, and C_3, form the coupling network between the coils and also tune the latter to the correct frequency. In practice, tuning is performed by the use of the iron-dust slugs that are an integral part of the coils' construction, but nevertheless, the capacities form the necessary tuning capacities as well as coupling the two circuits together. Actually, the coupling between the tuned circuits is given by C_3, which is common to both circuits. At first sight, it might appear impossible to predict the tuned frequencies of the two circuits, even if all values of capacity and inductance are known. However, this difficulty is easily resolved when it is realised that the frequency to which L_1 is tuned depends solely on the values of L_1, C_1, and C_3. Similarly, the tuned frequency of L_2 depends only on L_2, C_2, and C_3. In other words, to calculate the tuned frequency of one coil, it is only necessary to imagine that the other coil is open circuited.

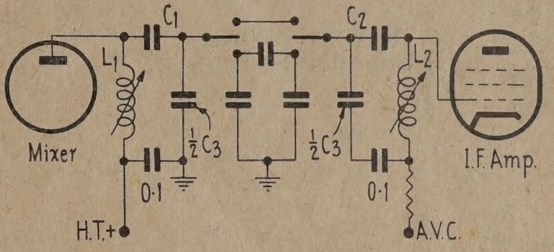

Fig. 5
This shows the actual arrangement of the circuit in the practical tuner, except that here, only two selectivity positions are shown.

The other point of interest is just how the relative values of the three condensers affects the degree of coupling between the tuned circuits. This again is quite a simple relationship, which can be stated:

$$k = \frac{\sqrt{C_1 . C_2}}{C_3} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

where k is the coupling coefficient. Since in our case, as in most we have $L_1 = L_2$, and since both are required to be tuned to the same frequency, C_1 must be equal to C_2, so that the above formula reduces to:

$$k = \frac{C_1}{C_3} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

Thus, it can be seen that it is a comparatively simple matter to get any value of coupling coefficient we choose simply by changing C_3 and then readjusting C_1 and C_2 to resonance. At this stage it is quite easy to visualize a scheme for varying k by switching in different values of all three condensers. This might appear comparatively simple, but a little thought will show that it is not very easy to accomplish satisfactorily. In the first place, C_1 and C_2 would have to be made variable and would have to be pre-set. This would make the proper adjustment of the system quite a difficult matter, especially in the "wide" positions of the selectivity switch. This is because in these positions the circuits will have to be very much over-coupled, and, when this is so, the tuning controls are not independent. In fact, if this method were used, it would hardly be possible to align the system at all without the aid of a frequency-modulated oscillator and an oscilloscope. Still, there is a way out of this difficulty, and it is here that Mr. Varrall has made his interesting contribution.

In Fig. 2 the system of Fig. 1 has been redrawn. Here, there is no difference except that C_3 has been split into two equal parts. One is connnected at each

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coil, and the condition of Fig. 1 is restored by joining the two junction points of the series combinations. Next in the evolution of the complete circuit is Fig. 3, where the link between the circuits is shown broken. Here, there have been added two switches. In the upper position of the switches, which are ganged, the connections are identical with those of Fig. 2 and therefore with those of Fig. 1. In the lower position, however, the network, N, is placed into circuit. It can be shown that if N fulfils certain conditions, it can cause the coupling coefficient to be reduced to any desired value, and at the same time to ensure that the tuned circuits remain tuned to the same frequency as before. Thus, if the values of C_1, C_2, and C_3 are chosen in such a way as to make k large enough for the greatest bandwidth that is wanted, the network, N, can be made to reduce the coupling to a value that is less than critical, in which event the double-peaked type of response disappears, and we have a normal sort of selectivity curve, used for reception under noisy conditions or for distant stations. If we assume that the appropriate kind of network N can be constructed, there is no reason why we cannot have as many selectivity positions as we choose, intermediate in effect between the "wide" position and the narrowest position. Since in the narrowest position the circuits are not more than critically coupled, the tuning of the circuits can be done in this position; thereafter, the properties of the coupling networks see to it that symmetrical expansion of the bandwidth takes place, and therefore that the circuits do not become detuned.

What, then, is required of the network N? Since it has to reduce the value of coupling between the circuits, it must attenuate the voltage that is transferred from one circuit to the other, which is merely one other way of saying the same thing. Thus, the first thing that is known about N is that it is an attenuator. The second requirement for N is that, when connected into the circuit, it shall not detune either of the tuned circuits. This looks like a difficult one to fulfil, until filter theory is brought to the rescue. Let us state the requirement in a different way. When the input end of the network N is connected to the point A, there must be a reduced voltage available at the output terminal of N, and also the connection of N must have no effect on the tuning of the circuit, L_1, C_1, C_2. Now, remembering that in the "broad" position we have reduced N to the proportions of a short circuit, it is seen that here the attenuation is zero, and that the circuit L_1, C_1, $\frac{1}{2}C_3$ is tuned correctly because a further condenser of value $\frac{1}{2}C_3$ is connected in parallel with the first one. Thus, the second requirement of N is that it shall have the same effect on the L_1 circuit as has connect- $\frac{1}{2}C_3$ across point A and ground. But this is not all. At the same time as doing this, N must appear to the point B exactly as if the first $\frac{1}{2}C_3$ had been connected

across it. This description of the action of N immediately brings to mind the behaviour of matched-impedance attenuators, whose purpose is not only to attenuate but also to see that its input and output impedances are each equal to the impedance of the circuits to which they are attached.

Now, although matched impedance attenuators are usually made up of resistors and are designed to match impedances that are purely resistive, there is no reason at all why we cannot have an attenuator made up of condensers, which will therefore match impedances that are purely capacitative. A little thought will show that this condition is the one with which we are attempting to cope. The network N, therefore, must be an attenuator, and its input and output impedances must each be equal to the reactance of the two condensers labelled $\frac{1}{2}C_3$. In order that the second of these conditions may be fulfilled, the network must be made up entirely of condensers. In order to act as an attenuator, it can have either the T or the π configuration usually employed in resistive attenuators. Fig. 4 shows in schematic form a two-point selectivity system in which the capacitive attenuator is of the π type. This is used in practice, too, because it leads to rather smaller values for the condensers than does the T-type attenuator.

In Fig. 5 is shown the same system as it appears in practice. L_1 is in series with the plate of the mixer valve, and the condenser network between this coil and L_2 serves to block the D.C. voltage from the latter, which is directly connected in the grid circuit of the I.F. amplifier valve, just as is the secondary of a normal I.F. transformer. The practical circuit is exactly equivalent to the circuits of Figs. 1 to 4, because the H.T. end of L_1 is at earth potential as far as signal is concerned, because of the bypass condenser at that point. Even if this component were not present, the same state of affairs would exist, because the last filter condenser of the power supply sees to it that the H.T. line is at earth potential for signal. Fig. 5 shows only one π section filter, giving two selectivity positions, but more positions can be added simply by adding more filters and the appropriate number of switch positions. Many readers will doubtless be interested in the formulae by which the condenser values can be calculated for any given pair of coils, L_1 and L_2. Since this article is essentially a practical one, the design formulae for the complete system will be found in the Appendix to the article.

ADVANTAGES AND LIMITATIONS OF THE PRESENT SYSTEM

To some, the scheme which we have outlined may seem unduly complex compared, say, with the one of switching a tertiary winding on an otherwise conventional I.F. transformer. The question therefore arises, "Is this complication justified by superior results compared with those obtainable by other and simpler methods?"

Depending on what the builder requires from his tuner, the answer could be either affirmative or negative. We will therefore attempt to give an unbiased assessment of the special merits and peculiar disadvantages of this circuit. At the outset, it may be said that on theoretical grounds, and also largely on practical ones, too, it is difficult to pick holes in it. The worst that can be said about the system is that for more than two selectivity positions it needs rather a larger number of fixed condensers and that the

values in the coupling networks should be correct to within plus or minus 5 per cent. We will have more to say about this aspect later, and will proceed to deal with various points under their appropriate headings.

(1) Ease of Application:

On this point, the present circuit scores heavily. Subject to the condition stated above, namely, that the fixed condensers should be accurate to within 5 per cent., no constructional difficulties occur. Similarly, alignment offers no special problems, and can be done with a signal generator and output meter. Some variable selectivity schemes cannot be properly adjusted without the aid of an F.M. signal generator and a C.R. oscilloscope. In all these respects this circuit is no worse and no better than the tertiary winding method. Like the latter, switching is done at a point of very low impedance, so that, although the points switched are carrying signal voltage, this is low in value. As a result, it is not necessary to shield the selectivity switch, nor is the system likely to be upset by stray capacities associated with the switch. Other systems involving switches for controlling the selectivity by no means comply with these requirements, which are most important if the system is to behave according to calculation. A further point in favour of the circuit being described is that it can be applied equally easily to any intermediate frequency and that the constants of the coils, L_1 and L_2, are not at all critical. All that needs to be known about these is the capacity with which they are designed to tune to the I.F. Nor does it matter whether they are to be permeability-tuned or tuned with variable condensers. Our circuit shows the former, because suitable shielded single coils of this nature are available. Mr. Varrall's original design, however, used condenser tuning. All that is necessary is to make C_1 and C_2 variable. All other condensers remain fixed, and these ones are used to tune up the system in the usual way.

(To be continued.)

BEACON TECHNICAL TOPICS

High Frequency Filters

With the advent of wider range sound reproducing equipment, the need for some means of limiting the high-frequency response when required has become desirable. In particular, when playing records with high surface noise with a good quality pick-up, the use of an adjustable filter network can make a vast improvement.

For this purpose Beacon makes two tapped coils, which, in conjunction with a double-pole three-position switch and the necessary condensers, forms a two-section pi filter with cut-off frequencies of 4, 6 and 9 kc/sec. At an octave above cut-off frequency the response is down approximately 30 db. in each case.

An advantage over the normal tone control is the rapid fall off, without any change in the volume level. This filter is designed to work in the 15-ohm secondary of an existing output transformer and can be placed ahead of a dividing network if one is used. If feedback from the voice coil is used, it may be found necessary to reduce the amount to avoid instability, in view of the change of phase of the secondary load as the filter is introduced into the circuit.

Both the dividing network mentioned previously and the high frequency filter are recommended more especially for triode amplifiers, where they work from a low impedance source.

Cat. No.

48 J 01 Air Core Coil for Dividing Network (two required).

48 J 02 Air Core Coil for H.F. Filter (two required).

Ian C. Hansen.

A Mutual Conductance Valve-Tester Using A New Principle of Measurement

Since the inception of this journal we have had many requests from readers for the design of a valve-tester which does not use components that are difficult to obtain and which gives an answer that means rather more than the usual "Good–Bad" scale found on many commercial instruments. The instrument described here fulfils these requirements, and is simple to build as well. The description is so written that constructors may put on as many or as few test sockets as are needed, without necessarily having to incorporate a complete range, many of which would be used infrequently. The tester will accommodate directly or indirectly heated valves, including the 1.4v. series.

INTRODUCTION

The commercial valve-tester is an expensive instrument, well outside the financial resources of most amateurs and home constructors, and, to-day, not very easily obtainable in any case. For anyone who does much work with valves, it is, if not an essential, an exceedingly useful adjunct whose possession can save untold time in searching for faults in equipment that does not perform as it should. If this happens, the first thing one wants to know is whether or not it is due to a faulty valve, particularly if some of those used are of uncertain age and/or are being used in an unusual circuit. As for the radio serviceman, there is no need to go into detail about his need for a valve-tester. Many servicemen or prospective ones may wish to tackle the building of a tester themselves, but do not have immediately at hand the design information they need. For these, too, this article should be of considerable interest; there is nothing difficult about this tester, either by way of construction or calibration. It gives readings directly in mutual conductance, and all that is necessary, apart from the instrument itself, is the normal amount of information contained in the manufacturers' valve-data books. The valve is tested in all cases under operating conditions that closely approximate those found in practice, so that, although no valve-tester can exactly reproduce practical conditions, this one approaches this ideal as closely as any other. In particular, it is much better in this respect than those which give an indication only of emission. A further point in its favour for those who wish to build their own valve-testers is the inexpensive nature of the parts used. The most expensive single item is a meter, 0 to 100 ma., on which the plate current of the valve under test is read. This need not be an expensive item either, as the accuracy of the mutual conductance reading is little affected by the accuracy of the plate-current meter. The indicator for the tester is a magic-eye tube, which is used only to indicate a standard audio voltage, so that the accuracy of testing is independent of this, too. The reading accuracy is concentrated in a calibrated potentiometer, which is given a scale marked directly in milliamps/volt, and the overall accuracy is therefore limited only by the accuracy with which the constructor can measure resistance. For normal valve-testing work the results will be quite accurate enough if the calibration is performed with an ordinary ohm-meter. Anyone desiring better performance than this has only to use a potentiometer that is accurately linear and which has been more rigidly calibrated.

PRINCIPLES OF OPERATION

Most valve-testers that measure the mutual conductance of the valve under test do so by the so-called static method, in which the valve is biased so that it draws its rated plate current, and a meter in the plate circuit reads the change in plate current produced by a shift in grid voltage of one volt, a switch having been arranged which changes the D.C. bias by half a volt on either side of the normal grid bias. This is much better than an emission test, but still does not guarantee that the valve will operate properly with an A.C. signal on the grid. The so-called dynamic mutual conductance testers use an alternating signal and either a dynamometer or rectifier type of meter to measure the alternating component of plate current. The former type of meter is not procurable in this country, while the latter does not give a very accurate answer. In the present design, which to the best of our knowledge is original, these difficulties are overcome by using a well-known property of the cathode follower and by arranging things so that the output indicator does not have to measure the output in volts or milliamps, but merely to indicate its equality to a voltage that is provided internally.

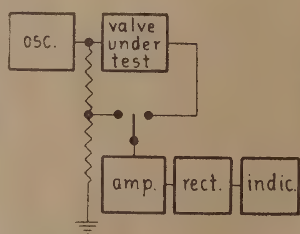


Fig. 1.

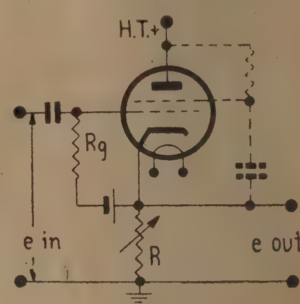


Fig. 2.

The principle of the mutual conductance meter can be followed by reference to Fig. 1, which is a block diagram of the system, including the valve under test, and to Fig. 2. The latter shows the valve under test, connected as a cathode follower. The dotted part shows the connection for the screen if the valve is a pentode. It can be shown mathematically that the output impedance of a cathode follower used at audio frequencies is very nearly equal to $1/_{gm}$ ohms, where $_{gm}$ is expressed in amperes per volt. Since the mutual conductance of all small valves is expressed more often as milliamps per volt, a more useful relation is: $R_o = 1000/_{gm}$ ohms, where $_{gm}$ is in ma./v. Now this relation is not rigidly true, as the two components that make up the output impedance are $1000/_{gm}$ and R_p in parallel. However, R is so high in value compared with $100/_{gm}$ that it has only a negligible effect on the output impedance in practically all cases. Now the above formula is

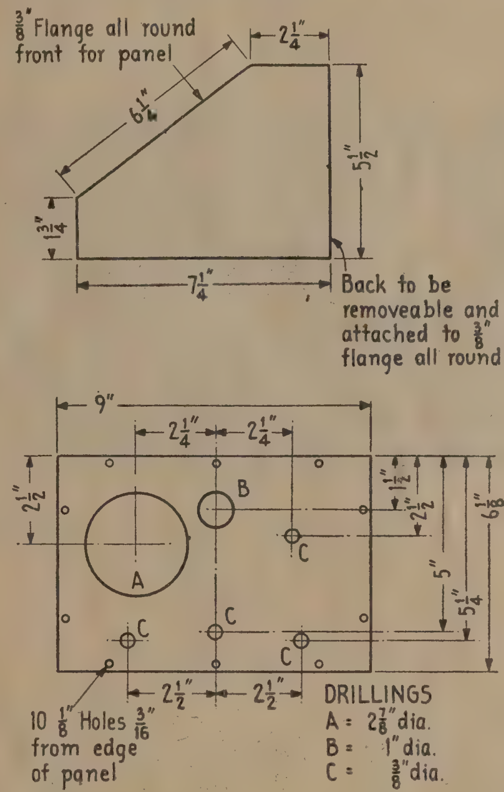
true only in the hypothetical case where the cathode load resistor is infinitely great. In this case, which can never be realized in practice, the gain of the cathode follower would be exactly unity. In any practical instance, the actual output impedance would be the resultant of $1000/_{gm}$, R_p, and R_1 all in parallel. Now, $_{gm}$ and R_p are properties of the valve, and cannot be altered by any circuit arrangements that may be made. R_1, the cathode load resistor, however, can be controlled, and if it is given a value equal to the output impedance of the cathode follower with an infinite load resistor, the gain of the cathode follower stage will be exactly 0.5. That is to say, the output voltage will be half the input voltage. This is simply an application of the completely general truth that if a generator is terminated by a load whose impedance is equal to the generator's own internal impedance, the loaded output voltage will be one-half the no-load output voltage. In other words, for the condition in which the gain of the circuit is 0.5, we have R_1, the load resistor equal to R_o, the cathode follower output impedance. But, as we have pointed out above, $R_o = 1000/_{gm}$, so that, by combining the two relationships, we get that $R_1 = 1000/_{gm}$ when the gain is 0.5. This is the basis of measurement, for, suppose we make R_1 a potentiometer, vary its value until the stage gain is 0.5, and then measure the value of R_1, we can work out the mutual conductance of the valve from the simple formula $_{gm} = 1000/R_1$ ma./v., where R_1 is expressed in ohms.

For example, supposing the value of R_1 is 200 ohms when adjusted to give the required stage gain of $\frac{1}{2}$, $_{gm} = 1000/200 = 5$ ma./v. Similarly, if R_1 is 1250 ohms, $_{gm} = 1000/1250 = 0.8$ ma./v., or 800 μmhos.

In making the measurement, we can adjust R_1 and then measure its resistance with an ohm-meter; if we like, the resistor can be directly calibrated in terms of mutual conductance. This is very useful, because it means that, in order to calibrate the instrument after it has been built, we do not need a standard valve or anything of that nature, but can perform the calibration purely by means of resistance measurements. This is one of the things which should make the design so attractive to amateurs and others not heavily equipped with test gear. In addition, for those who require very high accuracy this can be obtained simply by providing a very good potentiometer or else by using an accurate bridge to measure the resistance of R_1.

THE PRACTICAL SET-UP

The block diagram shows in general terms how the tester is arranged and how the measurements are made in practice. First of all, there is an audio oscillator, working at about 1000 c/sec. The frequency is not critical, but has been made high to obviate hum troubles. It would have been possible to use 50 c/sec. from the mains as the test signal, but this would more than probably give trouble from hum, especially in the testing of directly heated valves. The simple RC oscillator employs only one tube, and is well worth the slight extra cost for the way in which it preserves the accuracy. Naturally, if 50 c/sec. from the power supply of filaments were to get into the test circuit, the accuracy would be liable to be very poor. The oscillator feeds first into a voltage divider, made up of two equal resistors, and also into the valve under test. The remaining three blocks of Fig. 1 form the indicating circuit, which consists of an amplifier stage of moderate gain, a rectifier, and a magic-eye tube, which is the actual indicator. As can be seen, the input to the indicator circuit can be supplied, at the turn of the switch, either by the output of the valve under test, or by the oscillator itself, via the voltage divider. The latter is simply a source of signal, of an amplitude equal to one-half the signal voltage fed into the valve being tested. The oscillator has an output voltage control, not shown on the block diagram. The method of taking a reading is as follows: The switch is set so that the oscillator output is fed to the indicator circuit, and the output control is adjusted so that the eye just closes. The tester is now ready for a measurement to be taken. The switch is set now to the "Test" position, and the variable cathode resistor is adjusted until the eye is just closed again, indicating that the output voltage is equal to the audio voltage at the tap on the voltage divider.

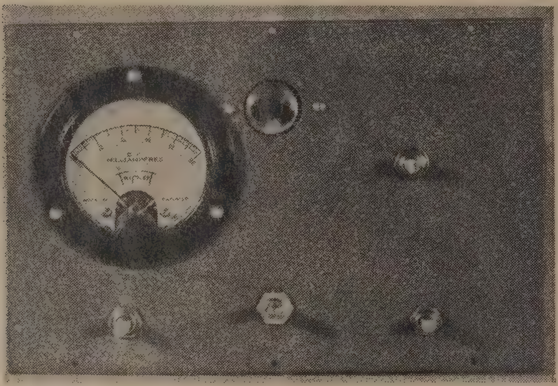


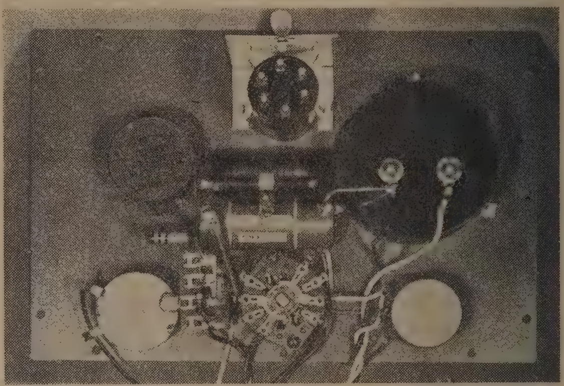
Chassis required for the main unit of the tester.

This is the fundamental measuring set-up. In addition to this, however, the complete circuit has arrangements for adjusting the grid bias in the tube under test, for supplying various screen voltages when voltage amplifier pentodes are being tested, and for measuring the plate current of the valve.

This latter facility is a necessary one, because it is only by adjusting the plate current of the valve to the value for which the valve-data book gives the mutual conductance that the correct answer can be given by the tester. This does not mean that the tester is correct only in these circumstances, but that, under different conditions, the mutual conductance will not be quite what the book states, for the simple reason that the valve "constants" are not con-

stant at all, but vary with the operating conditions. From this, it might seem necessary to make arrangements for adjusting not only the grid bias and plate current of the valve under test, but also the plate voltage. Fortunately, this is not the case, for it so happens that **as long as the plate current of a valve remains constant, the g_m will remain constant, too.** Thus, whatever combination of plate voltage and grid voltage is used to make the valve draw the required plate current, the mutual conductance will be the same. To take an example, the valve manual states that a 6J5, with 250 volts on the plate and a negative grid bias of 8 volts, passes a plate current of 9 ma., and has a mutual conductance of 2.6 ma./v. If we have a 6J5 whose characteristics agree exactly with those quoted by the manufacturer and we test it under these conditions, we will get the required answer of 2.6 ma./v. We will still get the right answer, however, if the plate voltage is 120 and the grid bias is —2 volts. This makes it quite unnecessary to have a plate supply voltage that is accurately known and adjustable for each valve type, for if there is a plate current meter and the grid bias is adjustable, the operating conditions can be adjusted simply by varying the bias until the plate current is the rated value.





Inside (right) and outside (left) views of the front panel of the tester, taken while under construction.

PRACTICAL ARRANGEMENT BY THE TESTER

In order to make the instrument a flexible one, it has been constructed in two units. The first contains the oscillator, the indicator circuit, and the power supply, together with the plate current meter, the calibrate/test switch, the grid bias adjuster, and the oscillator output control. The second unit contains the test sockets, the switches, or leads and plugs, which enable any valve to be connected in the appropriate circuit, the tapped filament transformer for the valve under test, and also switching arrangements for giving a low plate voltage for battery tubes and for giving a range of screen voltages for when small pentodes are being measured. The virtue of this arrangement is that practically all the essential "works" of the tester are concentrated in the small first unit, while all the wiring between the different types of test socket and the arrangements which have to be pre-set for each valve type are in the second unit. It is therefore possible for anyone who is interested in building the tester to make up the first unit, which remains the same under all conditions. Then, according as a great number of valve types have to be measured, or only a few, so the second unit can be made to suit individual requirements. For example, a home constructor might have standardized completely on the use of valves with octal sockets. In this case, only the one test socket need be provided, and the second unit will be a very small one. If at some later date the builder wishes to use and test, say, miniature valves, all he has to do is to install a miniature socket next to the octal one and parallel the pins which have corresponding numbers, i.e., both No. 1 pins are connected together, as are both No. 2 pins, and so on. However many additional sockets are wired in subsequently, the same wiring is done. In this way, by making the second unit large enough to take extra test sockets as and when they become necessary, the tester need never become out of date. Also, had we designed the instrument to be complete on one chassis, it would have been most inconvenient for those who do not need a large number of test sockets. The two units are joined by an eight-core cable terminating in octal plugs and sockets. We have drawn the circuits of the units separately, but if the preceding paragraphs have been carefully read, there should be no difficulty in following the diagrams.

SWITCHES OR WANDER-LEADS?

In any valve-tester there must be some arrangement by means of which the valve, when plugged into any of the test sockets, may be connected in the appropriate test circuit. In this tester, which gives only one type of test, the system is much simpler than when a variety of tests is catered for. Even so, the circuit diagram of the second unit looks a little fearsome, but this need not put anyone off, because the wiring is very easy to carry out in practice, and looks much worse on the diagram than it actually is. Before going on to examine the circuit in detail, it is necessary to look at the second unit and see how the right connections are to be made. As we have pointed out, the mass of wiring round the test sockets boils down to a very simple system, in which all corresponding pin numbers are connected together. This can be seen at the top right-hand corner of the second circuit diagram. Each pin on the test sockets is brought out to a lead marked with an arrow. There are nine of these altogether, one which goes to a cap connecter for the valve types

(Continued on page 34.)

WELLINGTON RADIO TRADERS' ASSOCIATION NEWS

The annual meeting of the Wellington Radio Traders' Association was held in Wellington on Wednesday, 4th August, 1948.

In moving the adoption of the annual report and financial statement, the President (Mr. D. B. Billing) referred to the successful termination of the last trading year, which he considered had presented no fewer difficulties than the previous few years. He drew attention, however, to the fact that the Association is still confronted with the question of membership strength, which he hoped would be built up considerably in the future. Continuing, he stated that, in the coming year, it would be desirable to approach the Government in an endeavour to find a solution to the present difficulty—the issue of import licences—and hoped that by this method dealings with the Customs Department would be on a more flexible basis than has been the case hitherto.

At this meeting the Association adopted its new constitution, which contained several important variations from that previously operative. The new rules provide for the inclusion of both wholesale and retail groups within the framework of the present Association, thus permitting greater flexibility for both sections of the industry.

The election of officers resulted as follows: President (re-elected), D. B. Billing; Executive—retailers' members: R. B. Fowler, P. B. Billing; wholesalers' members: W. L. Young, I. R. Cosgrave. The Secretary (G. C. Camp) and the Auditor (G. Y. Berry) were re-elected. Delegates to the New Zealand Radio Traders' Federation: D. B. Billing (President) and I. R. Cosgrave.

Following this, a lively discussion took place concerning various aspects of radio trade, including War Assets releases, valve-testing and other servicing charges, discounts, and further matters of common interest. This proved so interesting that, before making definite decisions, it was decided to discuss these points more fully at the next meeting. One important decision taken, however, was that the Association should issue an official badge to members.

Altogether, this proved one of the most interesting and heartening meetings yet held by the Wellington Radio Traders' Association.

CLASSIFIED ADVERTISEMENTS

Rates are 3d. a word, with a minimum charge of 2s. Advertisements must be to hand in this office not later than the fifteenth day of the month in order to be published in the issue appearing about the middle of the following month.

While all care will be taken, no responsibility can be accepted for errors. Advertisements should therefore be submitted either typed or printed in block letters.

FOR SALE, large Counter-type Simpson Tube Checker, with large 9 in. meter. This instrument is in first-class order and tests latest American tubes. £35. SOS Radio, Ltd., 283 Queen Street, Auckland, C.1.

FOR SALE, one A12 Jensen Speaker; 2500 ohm field; condition as new; £10 or near offer. Apply, 26 Woolcombe Terrace, New Plymouth.

DESIGN SHEET No. 3

We have received so many requests for copies of the only issue of "Radio and Electronics" which is out of print (December, 1946), and in particular for the Design Sheet No. 3, contained therein, that we have decided to reprint this feature.

THE DESIGN OF VENTED LOUD-SPEAKER ENCLOSURE

For many years a difficult problem in connection with sound reproduction has been that of providing an adequate baffle for dynamic loud-speakers. A theoretically desirable baffle is a very large flat sheet of rigid, non-vibrating material, near the centre of which the speaker is mounted, but the flat baffle, as it is called, takes up a great deal of space, and is therefore quite impracticable for many applications.

Perhaps the best of the many baffles which have been designed in attempts to overcome this space difficulty is the so-called vented baffle, or bass reflex enclosure. It is very simple to construct, gives even better results than a large flat baffle, and takes up no more room than the average console radio cabinet, so that, for many purposes, and particularly for home use where space is always at a premium, the vented baffle is an ideal solution.

The vented baffle consists only of a box made of some rigid material, such as heavy wood, and completely enclosed except for the hole in which the speaker is mounted and an additional hole forming the vent referred to in its name.

The important characteristics of the baffle are its internal volume (in cubic feet) and the area of the vent, both considered in relation to the mechanical characteristics of the loud-speaker unit used with it. The properties of the speaker which must be taken into account are:—

(1) The radius of the working part of the cone; and

(2) The low frequency at which the cone resonates.

This chart has accordingly been prepared to enable vented baffles to be designed with a knowledge of these two properties of the loud-speaker.

The cone-radius referred to is the radius to the edge of the conical portion, and should not be measured to the outside edge of the paper. This is because the only portion of the cone used to produce the sound is the conical portion, the flat or corrugated piece outside of this being used purely as a support for the cone proper.

BASS RESONANT FREQUENCY

When the cone of a speaker is tapped, a note is heard which corresponds to the free resonant frequency of the cone. However, this is **not** the resonant frequency required in the design of the vented enclosure. The resonant frequency required is that of the cone when the field is excited, and when the speaker is attached to a large flat baffle.

This frequency will have to be found either by measurement or by reference to the manufacturer of the speaker.

HOW TO USE THE DESIGN SHEET

First of all, measure the radius of the cone, as defined above, in inches. Secondly, measure or obtain from the manufacturers the bass resonant frequency of the speaker to be used. At this stage the internal volume of the box may be found from the graph. This is used as follows:—Find the radius value on the vertical scale, and travel horizontally until the curve is met which corresponds to the bass resonant frequency. Then, travel vertically to the volume scale and read off the volume of the baffle in cubic feet.

Example: The cone radius is 3 in. and the bass resonant frequency 90 c/sec. What should be the volume of the baffle box? Answer: 2.0 cubic feet.

SUBSEQUENT DESIGN

Having found the required volume, the shape of the baffle, within limits, may be chosen to suit the size of cabinet into which it is to fit, or to give a pleasing appearance. Fig. 1 shows a typical baffle whose internal dimensions are a, b, and c feet respectively. If the baffle is to be visible, it is a good plan to make b about 1.4 times a. Thus, suppose in the example above, the width "a" was fixed at 18 in. or $1\frac{1}{2}$ feet. Then the height "b" would be

$$1.4 \times 1.5 = 2.1 \text{ feet.}$$

Now, since two of the three dimensions have been fixed, the third side must be decided, since the volume is known from the chart. The depth therefore can be found from the relation

$$c = \frac{V}{a \times b} = \frac{2.0}{1.5 \times 2.1} = 0.64 \text{ feet}$$

Thus, the final dimensions of the baffle in the example are: 1.5 ft. × 2.1 ft. × 0.64 ft., or 18 in. × 25 in. × $7\frac{1}{2}$ in.

SIZE OF VENT

The remaining step is to decide on the size, shape and position of the vent or hole. The rule which fixes the size of the hole is that **it must be equal in area to the size of the working part of the cone.** We have already measured the radius of the working part of the cone in order to apply it to the chart. Its area is therefore πR^2 sq. in. or $3.14R^2$ sq. in. This is also the area of the vent. In the example given, the cone radius was 3 inches, so that its area is 28.26 sq. inches. The shape of the vent is not very important, but for best appearance a rectangular hole placed under the speaker is desirable. Thus, a rectangular hole 7 in. × 4 in. would be quite satisfactory.

PLACEMENT OF VENT

The vent should be placed as near as possible to the speaker. That is to say, any convenient distance may be used between the bottom of the speaker hole and the top of the vent as long as they are not too far apart. The proportions shown in the diagram Fig. 1 are quite suitable.

OTHER POINTS

For best results, the baffle should be lined with sound-absorbing material so as to prevent multiple reflections occurring within the box at the higher audio frequencies. Some soft material, such as wadding, may be used, held in place with glue. This will not affect the low frequency performance of the baffle, and can be disregarded in calculating the volume of the box.

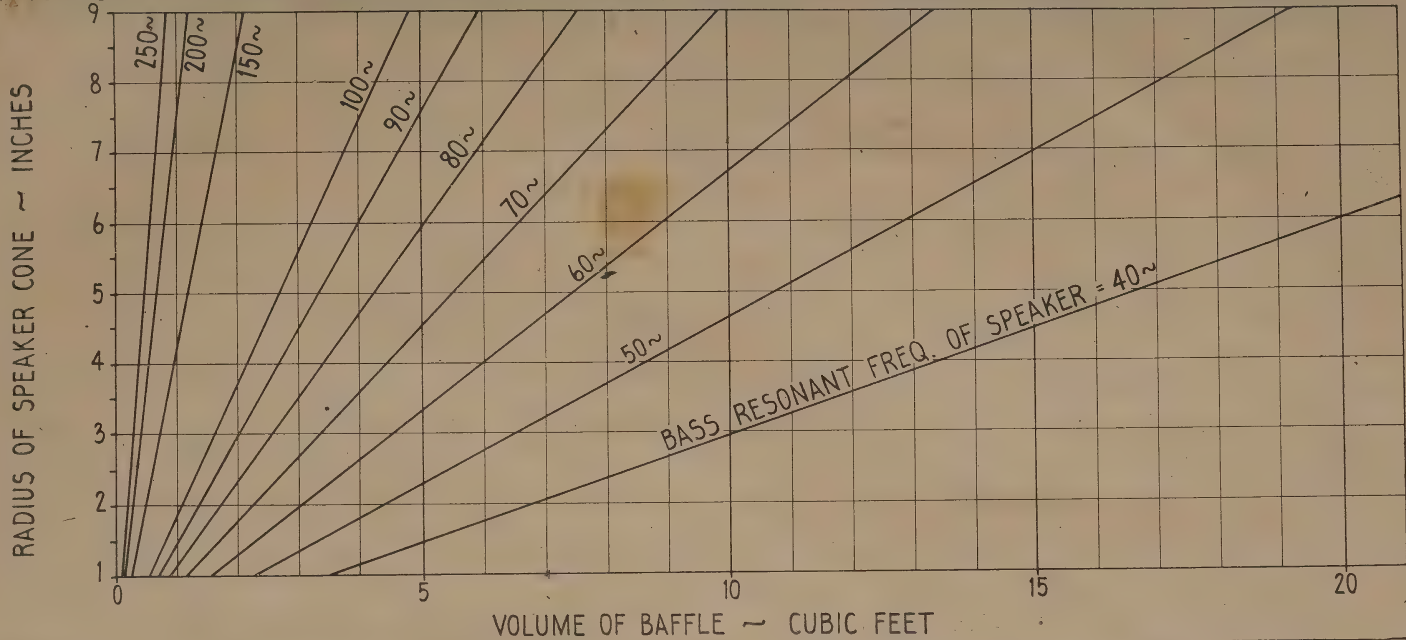
In specifying the volume of the box, no account has been taken of the space occupied by the speaker itself. It is as well, especially with bulky speakers, to estimate the volume occupied by the speaker and to add this to the volume obtained from the design sheet, but no great harm will come from neglecting this factor with most speaker units.

PERFORMANCE OF THE BAFFLE

The action of such baffles has been described frequently in the literature. Briefly, the basis of the design is that the resonant frequency of the air mass

DESIGN SHEET Nº3 :- Sizes of Bass Reflex (Vented) Baffles

EFFECTIVE RADIUS OF SPEAKER CONE *vs* VOLUME OF BAFFLE WITH BASS RESONANT FREQUENCY AS A PARAMETER



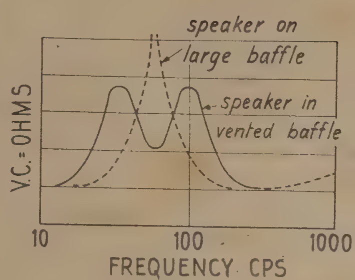


FIG. 2

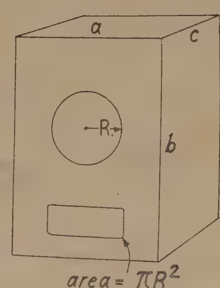


FIG. 1

(Continued from previous page.)

contained in the box should equal that of the loud-speaker cone. If this achieved, the effect on the low-frequency performance of the speaker is somewhat as in Fig. 2. The box greatly reduces the bass resonance of the speaker, by adequately loading it at this frequency, and instead produces two peaks in the impedance curve, one slightly higher in frequency, and one slightly lower than the original speaker resonance. Quality of bass reproduction is improved because of (1) the reduction in amplitude of the resonant rise, (2) the extension of the low-frequency response of the speaker, and (3) the fact that the vent acts in such a way that the low-frequency energy radiated from the back of the cone is projected from the vent in phase with that from the front of the cone, thereby increasing again the low-frequency output of the combination when compared with the same speaker unit used on a conventional flat baffle.

TUBE DATA: THE GERMANIUM CRYSTAL DIODE TYPE CG

Following its original work in the development of the stable Silicon Rectifier, the BTH has now produced an equally stable Germanium Rectifier, Type CG, of similar construction to the silicon type, but made only in the wire-ended form (1-C).

The Silicon Rectifier continues to occupy its unique position for all centimetre-wave applications; but, at the lower frequencies in more general use, the Germanium Rectifier has the definite advantage that it will operate satisfactorily at much higher voltages,

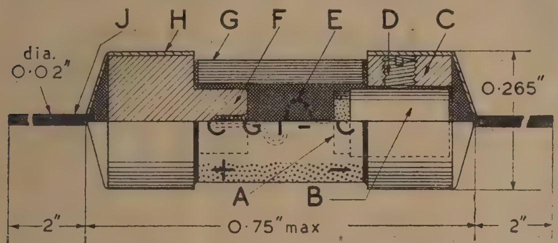


Fig. 1. Half-section of Germanium Crystal Rectifier, Type CG.

up to 80 volts. It is also better able to withstand transient overloads.

Crystal rectifiers possess certain inherent and obvious advantages over the thermionic-valve diode and the metal oxide rectifier. The diminutive Germanium Rectifier, **only ¼″ diameter by ¾″ long,** occupies only a minute fraction of the space of a thermionic valve, and, further, there is no heater supply, with its attendant 50 cycles hum, to be provided.

Compared with the metal-oxide rectifier, the Germanium Rectifier has, size for size, a far greater power-handling capacity, and the point-contact construction allows a much superior frequency response, due to the lower contact-capacitance. This characteristic renders the Germanium Rectifier particularly suitable for use in many high-frequency applications.

CONSTRUCTION

The general construction of a Germanium Rectifier is illustrated in Fig. 1. Crystal A, made of a specially prepared flake of germanium, is attached to the end of a plunger B, which after contact adjustment is locked in the metal sleeve C by the grub-screw, D. The tungsten-wire contact, or "cat's whisker," E, is brazed into a metal end-piece, F.

By a special process, the enclosing low-loss ceramic tube G is silver-plated at each end, and is soldered on to the sleeve C and the end-piece F.

The contact pressure between the crystal A and the contact wire E is adjusted to give a predetermined rectifying characteristic, and the plunger B is locked by the grub-screw D. The cartridge is then hermetically sealed, and the assembly is completed by fitting the end-caps H into which are brazed the nickel connecting wires J.

POLARITY MARKINGS AND CONNECTIONS

The body of the Germanium Crystal Rectifier is marked with positive and negative signs (Fig. 1) denoting the polarity of the voltage which, when applied to the rectifier, results in the "conduction" or "non-conduction" of current. It should be noted that the polarity markings on the Type CG rectifier are the same as those used on the corresponding American type, and are opposite to those generally used for contact rectifiers.

When soldering the end wires, care is necessary to minimize the conduction of heat to the rectifier itself; it is advisable to hold the wire with pliers close to the metal end-cap, to prevent damage by overheating. Otherwise the rectifier is remarkably sturdy. The assembly is tested to withstand a tensile stress of 20 lb. between the metal ends; and the contact stability is such that it will not be affected by normal mechanical shocks in handling.

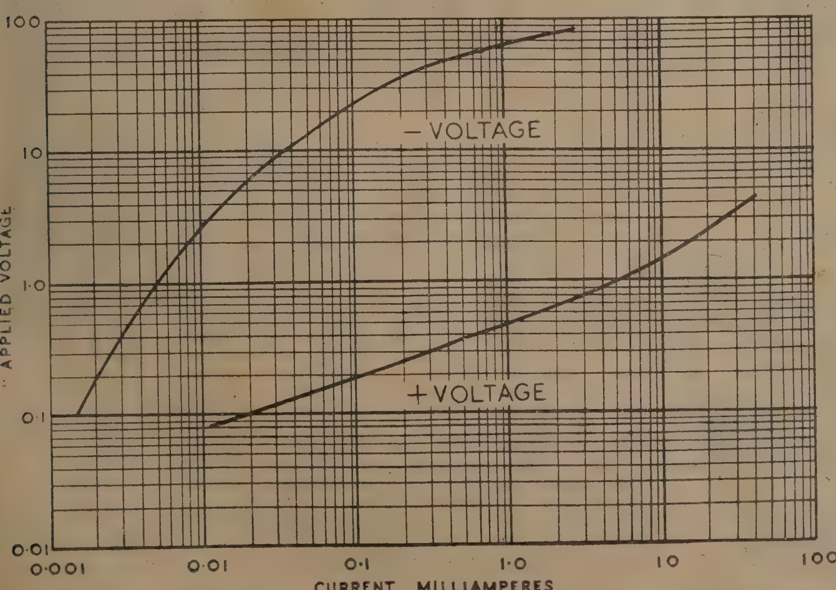


Fig. 2. Typical D.C. Characteristic Curves of Germanium Crystal Rectifier.

CHARACTERISTICS

Performance Curves

Figs. 2 and 3 illustrate graphically typical operating characteristics of the Germanium Rectifier. Fig. 2 shows D.C. characteristics, while Fig. 3 is a Frequency Response Curve.

Overloads

An important feature of the Germanium Rectifier is that it is not necessarily damaged by sudden or transient applications of excessive voltage. It will regain its normal characteristics almost at once, provided that the duration of the overload does not exceed a few milliseconds.

Temperature and Humidity

Each rectifier is hermetically sealed against the ingress of moisture, and may be used under tropical or arctic conditions.

Operating and Shelf Life

Provided that the voltage and current ratings are not exceeded, an operating life of several thousand hours continuous running may be expected. There appears to be no limit to the shelf life of the rectifier, judging by statistics available.

RATINGS

Max. Reverse Voltage .... — 80v. (peak value)
Max. Continuous Input Current 50 ma.
Max. Peak Input Current ...... 400 ma. (limited to one sec. duration)
Resistance at + 1 volt .... Not greater than 250 ohms
Resistance at — 50 volts ...... Not less than 50,000 ohms
Total Capacitance of Unit ...... 1.0 $\mu\mu$f. (average)
Max. Operating Temperature ...... 100°C. (with humidities up to 100%)
Min. Operating Temp. .... — 40°C.

CIRCUIT APPLICATIONS OF THE GERMANIUM CRYSTAL RECTIFIER

Second Detector

The Germanium Crystal Rectifier may conveniently be used as a Second Detector in low-impedance wideband I.F. amplifiers, up to 100 mc/s., with normal load impedance up to 5,000 ohms.

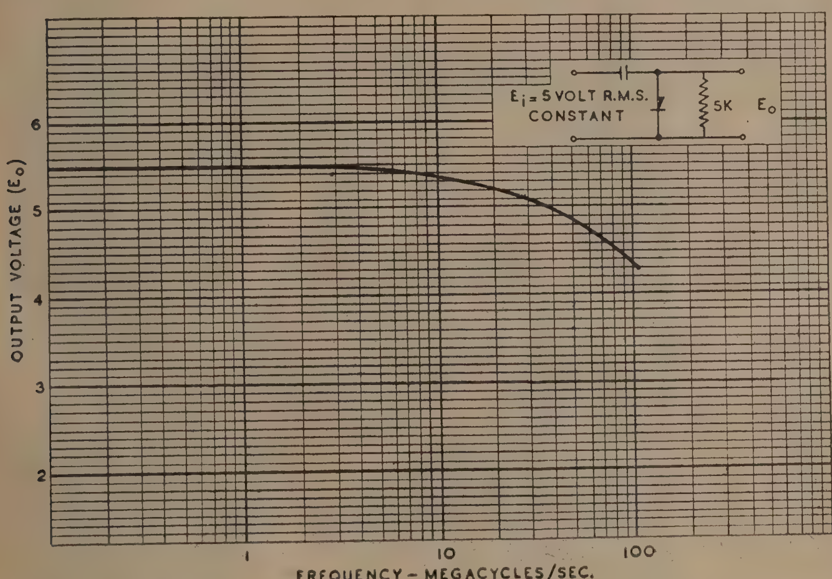


Fig. 3. Typical Frequency Response Characteristics of Germanium Crystal Rectifier.

Limiter

Considerable circuit simplification is effected by its use, with suitable load resistor and bias, in place of a diode.

D.C. Restorer

Its relatively low circuit loading and absence of heater connections provide a very convenient means of re-establishing the peak values of either positive or negative voltages to a given D.C. potential.

Discriminator

The Germanium Rectifier may advantageously be used for automatic tuning, and in Frequency Modulation systems, where superior frequency response and compactness are of importance.

Automatic Gain Control

It can be used in practically all types of receiver as the means of developing the A.G.C. bias voltage.

In addition to the above, the special and outstanding features of the Germanium Rectifier, its simplicity, and its small size, are employed to advantage in the following applications:—

Duty	Application
Power Rectifier	Miniature components development.
Pulse Generator	Modulating systems.
Rectifier	Telephone apparatus for A.C. operation.
Signal Generator	Power, voltage, or frequency monitoring.

The Frequency Response of Resistance-Coupled Voltage Amplifiers

PART II

WAYS OF EXTENDING THE HIGH-FREQUENCY RESPONSE

In order to see how the high-frequency response of the stage can be improved, we must look at Fig. 1 (a) again. The obvious method, that of decreasing the shunt capacities, has only limited application. Is there, therefore, any other way of achieving the desired end? There is; and it depends on the simple fact that the effect of a bypass condenser is greater, at a given frequency, the greater is the resistance across which it is connected. Thus, instead of decreasing C_{12} and C_{01}, we can decrease the value of R_1 and R_{g2} in parallel. This can be done either by decreasing R_{g2}, or R_{11}, or both, and it is here that the different behaviour of pentodes and triodes can be clearly seen. In the case of triodes, the plate resistance, R_p, is quite low—not higher than, say, 20,000 ohms for a medium-mu valve. Now, looking at Fig. 1 (c) again, it will be noticed that the shunt capacities appear in parallel not only with R_1 and R_{g2}, but with the plate resistance of V_1—namely, R_{p1}. A shunt capacity of, say, 50 mmfd. connected across these three resistances in parallel will not have very much effect below about 50 kc/sec., which is well above the audio range, and might at first sight seem to be so high as to be negligible. If a single stage were all that had to be considered, this amount of high-note loss certainly would be negligible, but, since a complete amplifier must as a rule contain three or more stages, the cumulative effect of two or more inter-stage couplings can be serious.

With a triode, the value of R_p, R_1, and R_{g2} in parallel is determined mostly by the plate resistance of the valve, because this is usually by far the smallest of the three. For this reason, when a low or medium-mu triode is used, very little improvement can be effected by decreasing R_1 and R_{g2}. The conclusion to be reached is that IF TRIODE VOLTAGE AMPLIFIER STAGES ARE USED, THE BEST HIGH-FREQUENCY RESPONSE WILL BE OBTAINED WITH THE VALVE THAT HAS THE LEAST PLATE RESISTANCE. At the same time, it is still important to see that R_{g2} is not made too high in value. High-mu triodes are to be avoided if high-frequency response is very important, because these valves have plate resistances as high as 60,000 ohms. This makes the shunt capacities more effective than they would be with a low-mu valve. If a high-mu triode must be used, there is considerable advantage in keeping R_1 and R_{g2} as low as possible, since in this case R_1 in particular is not very much greater than R_p.

With pentodes, the situation is very different. Our illustrative circuits have been drawn as triodes, but all that has been said applies equally well to pentode stages. The equivalent circuits of Figs. 1 (a) and (b) are applicable to pentodes also, and give the key to their vastly different performance with regard to frequency response. It is well known that a pentode has a very high plate resistance, measured in megohms rather than thousands of ohms. From what has already been said, it can be seen that this time, the component which largely controls the value of R_p, R_1, and R_g in parallel is now R_1, since it is now a good deal smaller than the other two. With pentodes and triodes the load resistors used are of the same order of size. The result is this, that with a medium-mu triode the value of the three resistances in parallel is somewhat less than 20,000 ohms, while with a pentode it is only slightly less than the value of the plate load resistor. Since this can have values from 100k. to 500k., it can be seen that the shunt capacities will have very much more effect than with the triode stage. Practically, this amounts to the fact that a pentode stage has a much better high-frequency response the lower the plate load resistor. If an attempt is made to get very high stage gain from a pentode by using a high load resistor, the gain is obtained at the expense of high-frequency response. If the amplifier is wanted to be flat up to 20,000 c/sec., and voltage stages are employed which use the ordinary type of sharp cut-off pentode, it is not possible to use a load resistor higher than about 100k. With a 250k. load resistor, the gain starts to fall off at about 10,000 c/sec., because of this high value, and without taking any other factors into account, such as additional stages. In short, if excellent high-frequency response is essential, it can be obtained by using either triodes or pentodes, but in each case precautions

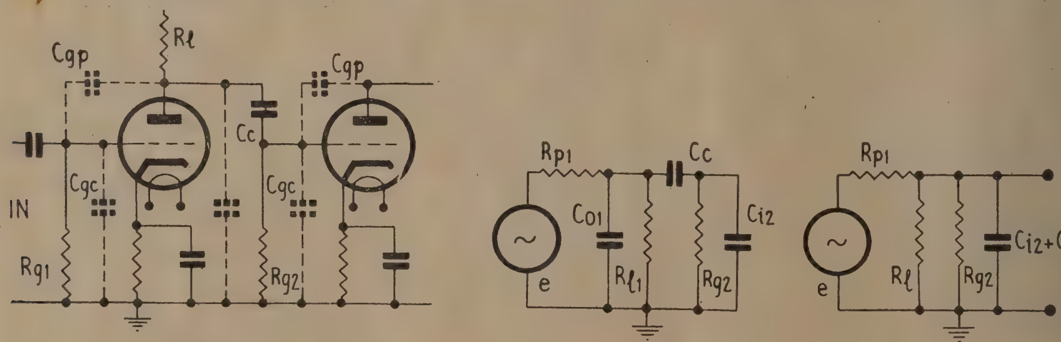


Fig. 1 (a). (b) (c)

have to be taken, especially when a number of stages are involved. As an example of what can be done, it may be mentioned that an amplifier designed in our own laboratory and afterwards described in these pages ("Radio and Electronics," August, 1947) used triodes throughout, comprising four stages altogether, not counting a special mixing stage in front of the amplifier proper, and to make matters more difficult used output valves with an exceptionally large input capacity. In spite of all this, the frequency response at the grids of the output stage, but with the latter working, so that its true input capacity was operative, was not down by 3 db. until 60,000 c/sec.!

This performance was attained by using low-mu triodes in the voltage amplifier section, by keeping the grid resistors down to 100k. on all stages, and by the special expedient of using a cathode follower buffer stage to isolate the grids of the output valves from the plate circuit of the last amplifying stage. Of course, frequency response of this kind is not normally required in an amplifier which is wanted only for the reproduction of music, but sometimes it is, especially when negative feedback is being applied.

With pentode stages, there is very little limit to the way in which the high-frequency response can be extended by decreasing the plate load resistor of the stage. At least, not so far as audio frequencies are concerned, for with present-day valves, the upper limit is in the region of 10 mc/sec.—about 50 times as high as is needed for audio work! It would seem, therefore, that an amplifier using pentode voltage amplifiers throughout would be the answer to the high-frequency problem. Unfortunately, however, there is more to the question than that. The difficulty is that decreasing the load resistor decreases the maximum undistorted output voltage of the stage as well. This may not seem very important when it is considered that modern pentode and beam tetrode output valves need only a very few volts of signal on their grids to drive them to full output. It is important, however, because in many instances negative feedback is applied to the output stage, from the plate circuit back to the grid, in which case the driving stage may be called upon to provide three or more times the signal voltage that is required if no feedback is employed. In fact, the increase in driving voltage required when feedback is taken only round the output stage usually limits the amount of feedback that is practicable. The input voltage needed to swing the output stage to full output may easily become more than the maximum undistorted output voltage of the last voltage amplifier. If this is the case, the only remedies are to use a voltage amplifier with a greater undistorted output voltage or to take the feedback round two or more stages. (See "Radio and Electronics," August, 1948, for an article describing two amplifiers of this sort.)

With most small pentodes used as voltage amplifiers (i.e., 6J7, 6SJ7, EF37, etc.), adequate high-frequency response is obtained when the plate load resistor is 100,000 ohms or less, and the maximum output voltage is in the region of 70v. peak. With 100k. in the plate circuit, the response starts to fall off in the neighbourhood of 20 kc/sec.

CAUSES OF LOW FREQUENCY FALLING OFF

There is virtually only one basic cause of the falling-off of the high-frequency response—namely, shunt capacities, but there are a number of reasons why the low-frequency response of an R.C. amplifier stage drops. However, the main cause is the voltage-dividing action that becomes evident between the coupling condenser, C_c, and the grid resistor, R_{g2}. This again is illustrated in Fig. 1 (b). As before, the valve is represented by a generator in series with a resistance equal to the plate resistance. What is immediately noticeable is that the inter-electrode capacities can be eliminated, thereby effecting a considerable simplification. This is quite in order, since, at the frequencies with which we are now concerned, the reactance of these capacities is so great that they have no noticeable effect on the performance of the stage. They can therefore be neglected. Now, suppose the generator has a frequency of, say, 400 c/sec., which is low enough for the stray capacities to have no effect but not low enough for C_c to have started to drop the output. We are left with the generator, R_p, R_1, and R_{g2} in circuit, and, as far as the signal is concerned, C_c can be regarded as a short-circuit. Thus the output voltage is $R_1/(R_p + R_1)$ times the generator voltage. Until the reactance of C_c becomes so great that its effect cannot be ignored, the output voltage of the stage remains at this figure, which is to say that the response remains level. As the frequency decreases, the reactance of C_c becomes greater. The voltage at the plate of the valve is still $e.R_1/(R_p + R_1)$, but the voltage actually delivered to the grid of V_2 is now less than this, because of the voltage-dividing action of C_c and R_{g2}. Thus, the lower the frequency, the greater the reactance of C_c and the smaller the proportion of the voltage actually at the plate of the valve that is applied to the V_2 grid. This behaviour is illustrated in Fig. 2 (b). The full line represents the low-frequency response for a certain combination of C_c and R_{g2}. If the latter is left constant, and C_c is varied, the performance changes as shown by the dotted curves. The one to the left of the full curve shows the effect of increasing C_c, while that to the right shows what happens when C_c is decreased. In words, the results illustrated by Fig. 2 (b) can be expressed as: "An increase or decrease in C_c causes the low-frequency response to extend or to become more restricted, respectively, if the value of R_{g2} remains unchanged."

The important thing to know about the way in which the coupling condenser affects the response at low frequencies is that AT A GIVEN LOW FREQUENCY, THE RESPONSE IS GREATER THE GREATER THE CR PRODUCT OF THE COUPLING CONDENSER AND THE FOLLOWING GRID RESISTOR. This indicates that the size of the grid resistor, too, has its effect on the low response. In fact, if R_{g2} is increased and C_c is kept constant, the response is improved in a similar manner to the way described for the variation of C_c. In this case, however, the effect is more complex, as altering R_{g2} has an effect on the mid-band gain, too.

The effect of the coupling condenser, as stated above, is the main one, but there are other things which can reduce the low-frequency response of an R.C. coupled stage. With a triode amplifier, there is only one other thing, and that is the effect of the cathode bypass condenser, when one is used. Of course, if cathode bias is not used (but it almost always is), there will be no other factors entering into the question. Also, in a pentode stage, there is the effect of the screen bypass condenser to be considered. The effect of these two compon-

ents is similar, and amounts simply to the fact that if either is too small, the low-frequency response will drop off faster than can be accounted for solely by the coupling condenser. What happens is this: If the bypass condenser is too small, a portion of the amplified signal voltage appears across the cathode resistor. In doing so, it is applied to the grid circuit of the stage, because the cathode is in both grid and plate circuits. It is, moreover, in the appropriate polarity partly to cancel the input volttage. In short, there is negative feedback. Now this, as is well known, reduces the gain of the amplifier. At the same time, it occurs only at those frequencies where the bypass condenser fails to act as a proper bypass—viz., at low frequencies. The situation is therefore that, however large the cathode bypass condenser is, a low frequency can always be reached at which the bypassing is not perfect, and at which the gain of the stage is therefore reduced by the negative feedback which arises. In practice, the frequency at which this effect becomes appreciable can be made low enough by using a sufficiently large bypass condenser. Thus, a 25 or 50 mfd. electrolytic condenser is more than big enough for this purpose in any audio amplifier circuit An interesting point is that, if the bypass condenser is omitted altogether, the response is much improved This is because there is now negative feedback at all frequencies

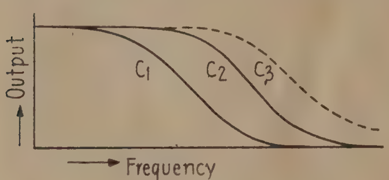
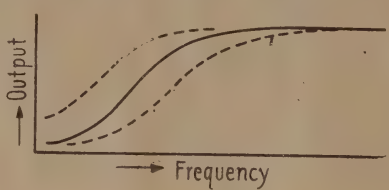


Fig. 2 (a).



(b)

The effect of insufficient bypass capacity on the screen of a pentode stage is very similar to that just described for the cathode bypassing of a triode, so that in a pentode stage we have to contend with three sources of drop: the coupling condenser, the cathode bypassing, and the screen bypassing. For this reason, unless special precautions are taken, the pentode stage tends to have a slightly worse response at low frequencies than does a triode.

METHODS OF KEEPING UP THE RESPONSE AT LOW FREQUENCIES

We have already indicated the causes of low-frequency falling-off, and so have indicated in some degree the precautions that must be taken. However, the matter is not quite so simple as might at first appear. The bypassing of the cathode and screen circuits is straightforward enough, but we should point out one further fact before we leave this subject. It is this: The higher the value of the resistor that has to be bypassed, the smaller the bypass condenser needs to be to keep the response up to a certain figure. In cathode-bypass circuits, this has very little bearing on the value of the cathode condenser used, except in special circumstances. The normal practice is to use a high-capacity electrolytic condenser. This is usually much larger than is necessary, purely from the point of view of the response, and is made so large for another reason—the suppression of possible hum. However, there is an important application of this fact to the bypassing of screen circuits of pentode stages. Some small pentodes require a very high screen-dropping resistor, 1.5 to 2 megohms, when used as audio amplifiers. In this case, one can get away with a comparatively small screen bypass condenser, of 0.05 to 0.1 μf. capacity. Others, however, use only 250k. ohms as the screen-dropper, and these need much higher values of bypass—up to 1 μf. or higher if the response is to be similar. This is a point well worth checking in appraising recommended circuits.

From the preceding paragraphs, it would seem a simple matter to ensure that the low-frequency response of an amplifier is as good as need be, because, in addition to looking after the cathode and screen bypassing, it might seem sufficient only to make the coupling condenser, too, extremely large. It is at this point that we begin to see that, although the high and low portions of the spectrum have been treated quite separately in this article (and in theory this is permissible), when it comes to designing an actual stage, the two cannot be completely separated. For, suppose we want to make the low response very good, and accordingly increase the coupling condenser, C_c to a very high value. This achieves the desired end all right, but we might be surprised, on taking a frequency check, to find that doing so has in some mysterious manner reduced the high-frequency response. The reason, however, is not far to seek. If we use a large paper or oil-filled condenser of 1 μf. or larger as C_c, the physical size of this condenser is found to be much greater than the 0.05 or 0.1 μf., components normally used. This means that there will be quite large stray capacities from the outside foil of the condenser to earth. These strays are directly added to the output and input capacities of the valves, and result in the extra drop that is observed at high frequencies. If we go the other way, and try to improve the lows by raising the value of R_{g2}, we remove the necessity for a very large coupling condenser, but at the same time run into one or both of two new troubles. The first of these is that there is an upper limit to the resistance that can safely be placed in the grid circuit of any valve. This maximum grid resistance is usually stated by the valve manufacturers, and it is not good practice to exceed this. The second effect is again one of extra high-note loss, and can come about because the increased grid resistance makes the input capacity of V_2 more effective than it was before. This is especially so when the grid resistance has to be in the form of a high-resistance potentiometer for volume control purposes. Thus, it can be seen that the design of a single stage is a matter of compromising between a number of conflicting factors. The requirements for good response at the high end are not altogether compatible, as we have shown, with those for good low response, and those of either can affect adversely the ability of the stage to give a large enough undistorted output voltage. The difficulty of getting enough voltage from the voltage amplifier to swing some output tubes, especially large, low-mu triodes, sometimes makes it impossible, with the available small triodes and pentodes, to realize the frequency response that is desired. However, this

situation does not arise to any noticeable extent with the receiver-type tubes that most of us are interested in.

THE EFFECT OF VOLUME CONTROLS

So far we have said nothing about the special problems introduced by the presence of a volume control, but this is most important, for this necessary piece of equipment can have a pronounced effect on the high-frequency performance of the whole amplifier if its value is improperly chosen.

Some way back, we had occasion to discuss Miller effect, and to show how the input capacity of a valve can be many times the inter-electrode capacities. This is most noticeable with triodes, which, as a result, have usually a much larger input capacity than pentodes. When a triode stage incorporates a volume control pentiometer as its grid resistor, the high-frequency response can be very much worse at some settings of the control than at others. It is found, if response curves are drawn, that with the volume control full on, and also with it close to the "off" position, the response is quite good, but that at intermediate positions of the control a very pronounced extra loss is apparent. This is due to the fact that with such a control, the resistance across which the input capacity is connected varies considerably with the setting. At low settings, the actual grid-to-earth resistance is quite low, and the effect of the capacity is even smaller than usual. Also, at maximum, the resistance (to A.C.) from grid to earth is governed by the plate resistance of the preceding valve, if it is a triode, or by the plate load resistor, if it is a pentode. Suppose the control has a resistance of 1 megohm. Now, when the moving arm is at the position of half-resistance, the A.C. resistance consists of the 0.5 meg. of the lower half of the control, in parallel with a **series** combination of the other (upper) half of the control and the plate resistance, or load resistor, of the preceding stage. Thus, the A.C. resistance to earth can rise from, say, 10,000 ohms when the control is at maximum, to about 250k. when the moving arm is at the half-resistance point. The result is therefore one of varying the resistance across which the input capacity appears between these limits, so that the high-frequency response varies considerably.

When the previous stage is a pentode, the variation is not so great, but the maximum effect is worse because here the minimum resistance when the control is full on is greater by a factor of 10 or more. In order that this undesirable effect may be as small as possible, two things can be done. The value of the control potentiometer can be reduced or the input capacity of the valve can be minimized. If the gain control is at the input of the whole amplifier, it is usually possible to use a fairly low value of potentiometer, except where the amplifier follows the diode second detector of a receiver. The easiest way to make the input capacity of the valve as small as possible is to see that a pentode or **low-mu** triode is used to follow the control. Another way of lowering the value of the control when other factors dictate a high value is to use a cathode follower between the input and the control. When this is done, a very low value of control potentiometer can be used between the cathode follower and the input to the next tube, even to the extent that it now becomes possible to use a high-mu triode, or one with a **high** input capacity, instead of a pentode, and still retain excellent high-frequency response.

SUMMARY

The conclusions arrived at in the above paragraphs can be summarized briefly as follows. Each rule or conclusion set down is correct in itself, but it should be remembered that some of the desired conditions for low and high-frequency response are mutually contradictory, and compromises in fixing values should therefore be made with these points in mind.

(a) Factors Affecting High-frequency Response:

(1) **Valve Capacities.**—These are the main consideration. For good response they should be as small as possible.

(2) **Grid Resistor of Following Stage.**—This should be as low as possible. The limitation on a very low value is that the undistorted output voltage of the stage is thereby lowered. Also, a very low value makes necessary an impossibly high value of coupling condenser for getting good **low-frequency** response.

(3) **Volume Control.**—This is a special case of the grid resistor affecting the high-frequency performance. Its effect is greatest at middle settings, and a high value can cause excessive high-frequency loss. With a pentode following, the effect is less than with a triode on account of the smaller input capacity of the former. With a pentode **preceding** the control, the effect is worse than with a triode preceding.

(4) **Choice of Triode or Pentode.**—With triodes, the high-frequency response does not start to fall off until well after the audio range, in a single stage, for any value of plate load resistor, but with a number of triode voltage stages in cascade, care is needed to see that the cumulative effect of the stages is not excessive.

With pentodes, the value of plate load resistor has a profound effect on the high-frequency performance. For flat response in a single stage, up to 20,000 c/sec., the load resistor should not be higher than 100,000 ohms. A valve with a high input capacity following the first stage has more effect on the latter's response if it is a pentode than if it is a triode.

(b) Factors Affecting Low-frequency Response:

(1) **The Size of the Coupling Condenser in relation to the Following Grid Resistor.**—If the CR product of these components is high, the low-frequency response will be good, and vice versa. The grid resistor cannot be made too large, because of the limitation in the maximum allowable grid resistance of valves, and because of the necessity for keeping this value down for (2) above. The maximum value of the coupling condenser is limited by the stray capacity introduced by a large condenser, this stray being added to the input and output capacities of the valves.

(2) **Cathode and Screen Bypass Condensers.**—These should be very large, and should be larger the smaller the value of cathode or screen resistor used. For applications where the low-frequency response is required to be better than usual (e.g., in oscilloscope amplifiers) it may even be desirable to increase the screen bypass to 8 mfd. or higher.

(c) Factors Affecting Undistorted Output Voltage:

(1) **Size of the Following Grid Resistor in relation to the previous Plate Load Resistor.**—The former should always be several times the latter if maximum undistorted output voltage is wanted. In early stages this condition may be relaxed to some extent,

(Continued on page 48.)

The "Radio and Electronics" Abstract Service

AUDIO EQUIPMENT AND DESIGN:

Quiet high-gain amplifier. Circuit and design of three-stage amplifier with p.p. circuits in each stage, with high value of common cathode impedance. First stage a "Schmitt" phase splitter using double triode valve. Gain 29.6. Second stage, double triode valve. Gain 20. Final stage, a pair of 4½-watt output pentodes in p.p. Gain 29.6. Negative feedback type of tone control.—**Wireless World (Eng.), June, 1948, p. 208.**

Single-diaphragm loudspeakers. Description of experiments in development of a loudspeaker for which advantages are claimed over twin-diaphragm "Tweeter" speakers, to give wide frequency response and effective damping. Modification to moving coil, cone shape, and method of damping.

—**Wireless World (Eng.), June, 1948, p. 218.**

Wide-range gramophone amplifiers. System employing two separate amplifiers, one for range 20-1000 cycles, the other for 100-20,000 cycle range. Low-frequency unit drives three or four-inch speaker; high-frequency unit drives twelve to fifteen-inch speaker. Circuits given for both simplified, and for more expensive system of higher output. Suggestions for loudspeaker mounting.—**Radio News (U.S.A.), June, 1948, p. 62.**

Recording and reproduction of sound. Further article in series. Part 16 deals with the performance testing of power amplifiers used in recording units.

—**Radio News (U.S.A.), June, 1948, p. 65.**

Bass boost. Description of volume control circuit used by one (U.S.) manufacturer to give desired bass boost characteristics over wide range of output levels. General rules to be followed in designing amplifiers with bass boost. Circuit of beat-frequency audio oscillator and method of operation for plotting response curves.—**Service (U.S.A.), June, 1948, p. 18.**

Electric megaphones. Brief discussion of general operation, capabilities, coverage, and uses. Electric megaphone is portable public-address system in two units: (1) Microphone and loudspeaker in one unit; (2) amplifier and battery connected by flexible cable to (1).—**Service (U.S.A.), June, 1948, p. 25.**

ANTENNAE AND TRANSMISSION LINES:

Short receiving antenna design factors. Particular application to aircraft use. Equations and graphs to assist in designing short receiving antennae with an electrical length of less than 10 degrees, at standard broadcast frequencies. Consideration of problems involved.

—**Communications (U.S.A.), May, 1948, p. 26**

Wide-range dual band (54-88 and 174-216 mc.) TV antenna design. Details of a dual-band antenna of simple construction.

—**Communications (U.S.A.), June, 1948, p. 12.**

Transportable 10-meter beam antenna. Constructional details of lightweight three-element beam weighing 16 lb., including elements.—**QST (U.S.A.), June, 1948, p. 44.**

CIRCUITS AND CIRCUIT ELEMENTS:

Schematic diagrams. Method described of preparing schematic diagrams in a form which simplifies the reading of complicated circuits. Design follows "flow-of-function" principle and proceeds from block diagrams to complete, detailed circuit based thereon. Advocates identification of components on the drawing rather than reference to an appended list of parts.

—**Electronics (U.S.A.), June, 1948, p. 74.**

Improving circuit diagrams. A commentary, with quotations, upon a new edition of the publication "Inter-Service Standard Graphical Symbols" (Eng.; available only to fighting services and their contractors). The publication referred to contains recommendations "leading to greater clarity in circuit diagrams"—**Electronic Engineering (Eng.), June, 1948, p. 175.**

Shunt voltage stabilizer. Analysis of circuits of both bridge feedback shunt voltage regulators, both A.C. and D.C. coupled. Worked examples of practical design, using triode valves.

—**Wireless World (Eng.), June, 1948, p. 200.**

Design of free-running multivibrator by graphic method. Curves given for all factors determining circuit operation, based on commonly used (U.S.) valves, and with a nomograph inter-relating these factors. Method facilitates quick and accurate design without need for recourse to elaborate calculations.

—**Electronics (U.S.A.), June, 1948, p. 118.**

Versatile power supply to provide both A.C. (continuously variable from 0-1, 200 volts) and D.C. (0-500 volts maximum—fixed and regulated) from 1200 v. centre-tapped transformer. Power supply unit intended for meter testing. Four 6L6G type valves, triode connected used in parallel as series regulators, and 6SJ7 type used as amplifier; 200 ma. rating. Uses Variac for A.C. variation.

—**Electronics (U.S.A.), June, 1948, p. 126.**

Regulated D.C. supply. Suggestions for further improvements in voltage regulators. Improved stabilization and regulation, reduced internal impedance and hum. Effected by inclusion of potentiometer in screen supply circuit of control valve so that small amount of unregulated voltage is added to reinforce regulating action of control-grid potential. Addition of a condenser-resistor combination made to provide a starting-time delay for limiting initial voltage surge during heating of control valve. Design and constructional details of an improved power supply. Bibliography: Voltage Regulators: included.

—**Radio News (U.S.A.), June, 1948, p. 68.**

A.C. operated triodes. A graphical method for investigating circuit conditions. Design of a sensitive relay using triode valves supplied with anode voltage from A.C. mains and suitable for controlling a load of 2 kw.

—**Electronic Engineering (Eng.), June, 1948, p. 178.**

Electronic alphabet generator. Details of circuits and apparatus for reproducing letters of the alphabet on CRT screen. (See "Radio and Electronics" Abstracts for July, 1948, p. 15; numeroscope reference.)

—**Electronic Engineering (Eng.), May, 1948, p. 139.**

A single-sweep time base. Used in examination of phenomena having a time period of between 10 milliseconds and 10 seconds. Details of simple time-base generator requiring only condensers and resistors. High-tension supply from CRT E.H.T. source.

—**Electronic Engineering (Eng.), May, 1948, p. 160.**

Stabilized power supplies. Correspondent to journal cited draws attention to error in formula, and author gives further correction. (See "Radio and Electronics" Abstracts, July, 1948, p. 15.)—**Electronic Engineering (Eng.), May, 1948, p. 169.**

Low-noise amplifier. Triode valves in low-noise cascade circuits, using grounded-cathode first stage and grounded-grid second stage (R.F.). Basic circuit and typical practical circuit briefly analyzed.—**Communications (U.S.A.), May, 1948, p. 25.**

Cathode-follower precautions. Reference to application note in "Radiotronics" (U.S.A.) warning against use of 6AG5 and 6AK5 miniature valves in cathode-follower circuits for reason that internal shields of these types are connected to cathodes and cannot therefore be earthed as they should be. Recommended types for c-f service are 6AU6 and 6BA6.

Electronic Engineering (Eng.), June, 1948, p. 186.

Bass correction in moving-coil pick-ups. Circuit for pre-amplifier giving bass boost through use of high-pass filter for negative feedback in cathode of pentode valve.

—**Electronic Engineering (Eng.), June, 1948, p. 187.**

Detector for single-sideband reception. (See "Radio and Electronics" Abstracts, September, 1948, p. 26, ref. "Electronics," May, 1948, p. 82.)—**QST (U.S.A.), June, 1948, p. 11.**

Low-pass audio filters. Operation and design. Simple formulae used in designing low-pass filter for speech amplifier of amateur transmitter.—**QST (U.S.A.), July, 1948, p. 18.**

FREQUENCY MODULATION:

Checking F-M transmitter frequencies. A v.h.f. checking procedure making use of WWV transmissions. Circuit and details of a secondary standard. 6F6 valve as oscillator drives 10 k.c. multivibrator which in turn drives 2 kc. multivibrator, the latter being included for experimental use only. Two stages of amplification used to increase harmonic output up to 110 mc. Isolation amplifiers employed for stability. Oscillator crystal provides either 1000 kc. of 100 kc. signals, the former frequency for reference purposes, the latter for beating with WWV. Frequency measuring procedure outlined.

—**Communications (U.S.A.), May, 1948, p. 16.**

Crystal-controlled reactance modulator unit for narrow-band F-M. Circuit and constructional details of lightweight, compact unit used as modulator for amateur transmitting operating on 28 mc.—**Wireless World (Eng.), June, 1948, p. 221.**

INDUSTRIAL APPLICATIONS:

Soldering aluminium alloys, stainless steel, chromium-plated and other surfaces. Details of experimental equipment used for sonodizing. Sonodizing defined as the tinning of aluminium and its alloys through application of magnetostrictive forces to a soldering-iron. Solder is vibrated at ultrasonic rate whilst it is being applied to the work; this breaks up oxide coating on surfaces and permits alloying of the metals before re-oxidation occurs. Magnetostriction generator consists of four 50-watt amplifiers in parallel, a capacitor loading unit, a tunable oscillator covering 7-70 kc., and a magnetostriction unit. Soldering-iron consists of nickel tube with tip made of stainless steel rod.—**Electronics (U.S.A.), June, 1948, p. 92.**

MEASUREMENTS AND TEST GEAR:

Test instruments in the broadcast station. Part 3. Use of R.F. bridge, decade resistance box, and field strength meter.

—**Communications (U.S.A.), May, 1948, p. 23.**

Circuit and design of a meter for measuring with CRT the phase angles of high or low-frequency polyphase voltage supply. Developed for work with 2H21 type (U.S.) phasitron valve. Circuit given of circular-sweep generator for CRT, operation described.

—**Electronics (U.S.A.), June, 1948, p. 142.**

Modulation percentage of A.M. signals. Method of using oscilloscope for visual reproduction of modulation patterns. Typical screen patterns to aid in interpretation of results.

—**Radio News (U.S.A.), June, 1948, p. 52.**

Vacuum tube voltmeter. A compact, portable, dry-battery operated VTVM. Construction details. Four triode-connected 3S4 type valves in cathode-follower, balanced bridge circuit. Range 0-1500 volts in four steps.

—**Radio News (U.S.A.), June, 1948, p. 60.**

Telegraph distortion measuring set. Circuit and operation of T.D.M.S. using phanastron time-base and multiar "pick-off." Application—measurement of distortion in teleprinters.

—**Electronic Engineering (Eng.), June, 1948, p. 181.**

V.H.F. impedance meter. Description of meter which operates on similar principle to that of aircraft F-M terrain clearance indicator. It is a frequency-scanning reflection meter which operates in 10-250 mc. range. A wide-range sweep oscillator scans a bandwidth up to 30 mc., output signal is applied to selected one of three fixed lengths of co-axial transmission line, to the end of which is connected the system under test. The transmission line sections act as delay lines. The reflected signal, which constitutes the output signal of the unit, is proportional to the amount of energy reflected from the end of the delay line. It is arranged that there is visual representation of impedance v. frequency.

—Electronics (U.S.A.), June, 1948, p. 94.

Dynamic distortion detector. Outline of monitor which indicates source of distortion in broadcast transmissions, whether arising from a unit at the studios or at the transmitter. Detector gives instantaneous visual indication of source and may be calibrated to read percentage distortion.

—Wireless World (Eng.), June, 1948, p. 213.

Distortion analysis. Clipper circuit to provide either clipped or double-clipped sine waves. Unit designed to give quick analysis of a linear circuit by noting on CRT the change in shape of certain standard waveforms. Application to investigation of class B amplifier, inter-stage transformer, high-quality amplifier, and communications amplifier described. Changes in waveforms at various frequencies illustrated and interpreted.

—Electronics (U.S.A.), June, 1948, p. 114.

RECEPTION AND RECEIVERS:

Post-war receiver design. Series dealing with special design features of U.S. post-war receivers. Part 1. Construction and operation of types of F-M—A.M. tuner units.

—Radio News (U.S.A.), June, 1948, p. 46.

Gang tuning in superheterodyne receivers for use on amateur bands. Use of shielded, permeability-tuned plug-in coils advocated, to give correct and easily adjusted tracking. Circuit and design of R.F. and oscillator stages. Coil winding details using specified types of coil formers.

—Radio News (U.S.A.), June, 1948, p. 48.

Adding single-sideband selectivity to a communications receiver. Circuit design and construction of a converter and I.F. channel for use with any broadcast or communications receiver employing I.F. between 450-500 kc. to give increase in selectivity and reduction in noise. Unit described, which incorporates specially designed 100 kc. I.F. transformers and new type of miniature valve, is commercially (U.S.) manufactured but may be duplicated if suitable parts available.

—Radio News (U.S.A.), June, 1948, p. 54.

Co-axial line receiver for 220 and 225 mc. Super-regenerative receiver with co-axial line detector circuit.

—QST (U.S.A.), June, 1948, p. 25.

Practical single-sideband reception. Description of a receiving system which is reverse of that employed in s.s.s.c. transmission. (See under Transmission and Transmitters, below.) System will select either sideband of A.M. or P.M. signal. Details of exalted-carrier demodulator, with automatic carrier synchronization, used for detection of s.s.s.c. signals containing small amount of carrier for "lock-in" purposes.

—QST (U.S.A.), July, 1948, p. 11.

TELEVISION:

Selectivity in TV amplifiers. Necessity for TV wide-band R.F. amplifiers which will give constant amplification over the band of frequencies radiated by vision transmitter, and attenuation of frequencies outside that band. Particular reference to TV transmissions from Alexandra Palace—carrier frequency 45 mc., modulation frequencies up to 3 mc., therefore full radiated band is 42-48 mc. TV sound is radiated on 41.5 mc., or 0.5 mc. below lower pass-band. Response curve of receiver must have cut-off slope of at least 54 db./mc. to avoid interference with vision signals. Consideration of means of achieving objective. Improvement gained by adoption of single side-band, or vestigial side-band reception and this referred to.—Wireless World (Eng.), June, 1948, p. 204.

Flying spot video generator. Notes on a newly-developed (U.S.) CRT enabling TV stations to construct a video signal generator for transmission of station call letters or test patterns from slide transparencies. Tube provides small, rapidly moving spot of radiant energy for scanning, has extremely short persistence phosphor screen with large component of energy emission in near-ultraviolet region. Short-persistence screen minimizes trailing in reproduced picture. Block diagram of video-signal generator using the new tube.

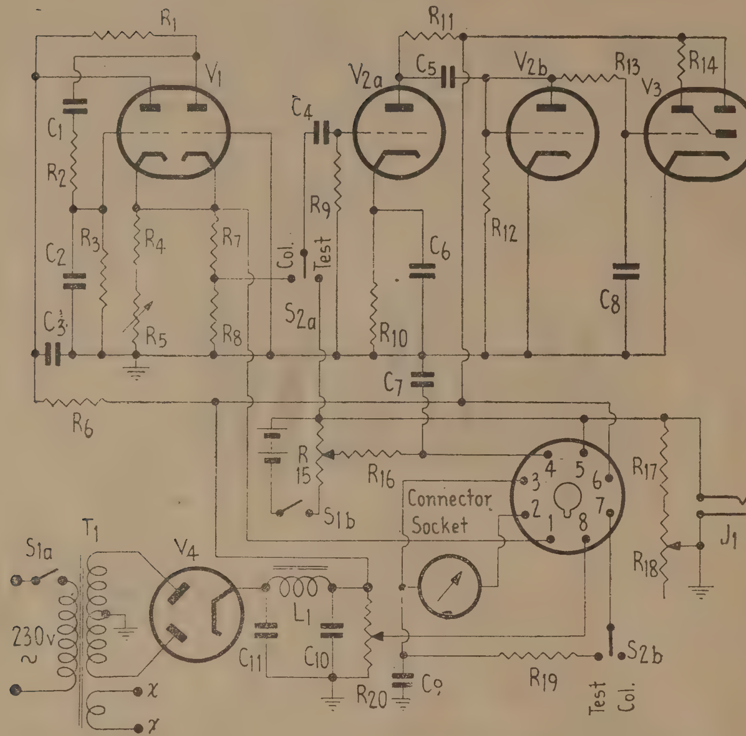
—Electronics (U.S.A.), June, 1948, p. 124.

Modern television receivers (U.S.). Part 3. Mixer and oscillator stages. R.F. alignment data.

—Radio News (U.S.A.), June, 1948, p. 71.

Improved pulse frequency divider. Modification of step-divider circuit to overcome limitations of that circuit. Provision for

(Continued on page 48.)



CIRCUIT OF THE FIRST (MAIN) UNIT OF THE VALVE-TESTER

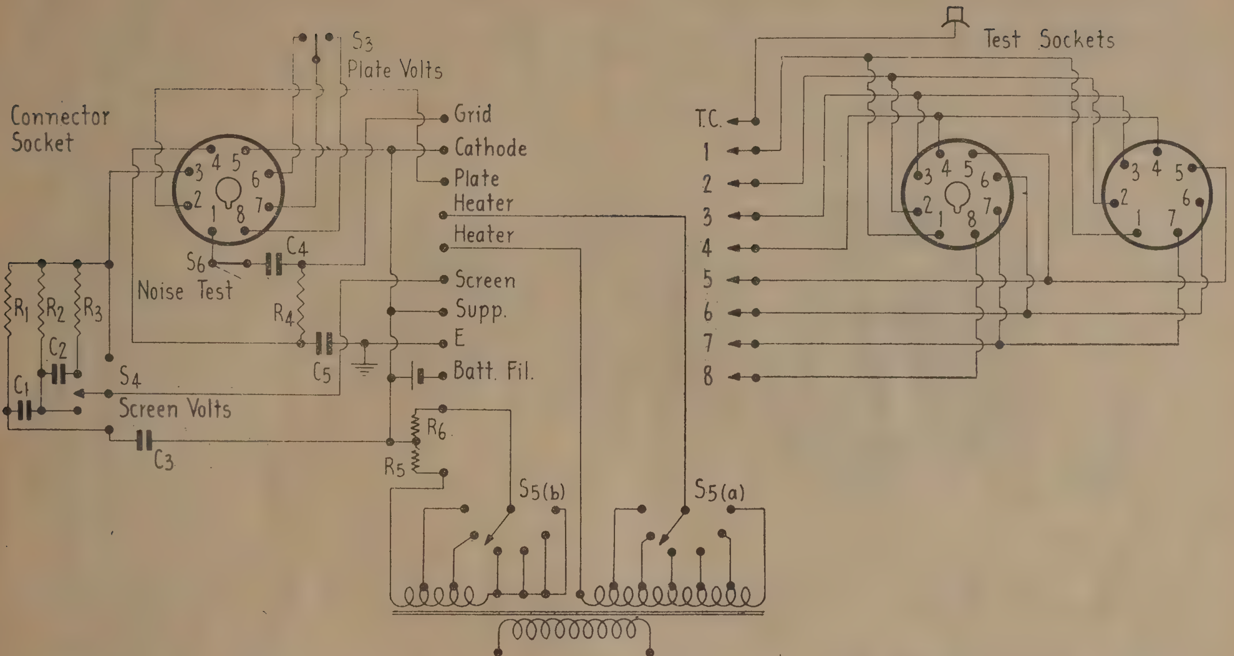
R_1 = 100k.
R_2, R_3 = 50k.
R_4 = 35k.
R_5, R_{15} = 25k. pot.
R_6 = 15k.
R_7, R_8 = 25k.
R_9, R_{12}, R_{13}, R_{14} = 1 meg.
R_{10} = 1200ω.
R_{11}, R_{16} = 250k.
R_{17} = 50ω.
R_{18} = 1000ω pot.
R_{20} = 5000ω, 25 watts, adjustable.
R_{19} = 1000ω 25 watts.
C_1, C_2 = 0.001 μfd.
C_3, C_9, C_{11} = 8 μfd. 400v. electro.
C_4, C_5 = 0.0005 μfd.
C_6, C_7, C_8 = 0.05 μfd.
C_{10} = 16 μfd. 400v. electro.
V_1, V_2 = 6SN7.
V_3 = 6E5.
V_4 = 6X5.
Meter = 0–100 ma.
Batt. = 18v. dry.
S_1 = D.P. On/Off.
S_2 = D.P.D.T. Cal./Test.
J_1 = Open cct. phone jack.
T_1 = 280–0–280v. 60 ma.
L_1 = 60 ma. smoothing choke.

that need one, and the other eight of which go to a pin on the test socket. We have shown the case of two test sockets only, an octal and a miniature. The miniature has no pin No. 8, so that lead No. 8 has no connection to the miniature socket. For the moment, we can imagine that the numbered arrows on the diagram represent wander-leads, terminated in plugs. It will be noted that on the left of the circuit there is a vertical row of dots in which the test circuit terminates. These dots have been labelled with the names of the valve elements to which the dots must be connected. The dots can therefore represent banana sockets into which the numbered plugs may be placed. Now, the same point on the test circuit, to the left of the row of sockets, always goes to the same valve element. The purpose of the wander-leads and plugs is simply to take care of the fact that not all octal-based valves use the same base-pin for the same valve electrode. For example, most, but not all, octal-based valves have the plate connected to pin No. 3. If all octal valves had this connection, it would be possible to connect the No. 3 pin on the octal test socket permanently to the banana socket labelled Plate. The same holds for all other elements and pins, so that it becomes necessary to have a flexible arrangement whereby any valve pin in any type of test socket may be connected to any of the points on the test circuit. The system illustrated is the easiest to construct and takes the smallest number of parts. Commercial valve-testers invariably have a number of multi-point switches instead of the plugs and sockets, but the principle of their action is exactly the same as outlined here. From our circuit, it should be possible for anyone who is used to reading circuit diagrams to transform the arrangement into one of switches if so desired.

In this case, the arrowed leads on the diagram would each represent the moving contact of one switch. The test circuit has nine points labelled Grid, Cathode, etc., so that the nine switches would need a minimum of nine positions each. The corresponding contacts of each switch would be paralleled and connected to one of the test circuit points. For example, all No. 1 switch contacts would be connected together, and a lead would be taken from the paralleled contacts to the point labelled Grid on the diagram. This would then enable any of the arrowed leads to be connected to this point. Thus, in setting up the instrument to test a valve whose grid comes out to pin No. 5 on the socket, switch No. 5 would be turned to position 1, thus connecting the grid to pin No. 5 on the connector socket and thence to the input signal from the oscillator. Whether the wander-lead or the switching system is used can be left to the discretion of the builder. For simplicity, small amount of wiring, and the minimum number of parts, the wander-lead system has distinct advantages over the switching. The latter, however, makes a neater job. If anything, the former is easier to work, for unless the switch points are labelled with the names indicated on the circuit for banana sockets, it is always necessary to refer to a chart which indicates the correct settings for the switches. With the wander-lead system, however, the sockets can easily be labelled in this way, so that for all valves for which the connections can be remembered, it is not necessary to refer to a chart in order to set up the test circuit.

THE CIRCUIT IN DETAIL

Having, we hope, elucidated the part of the circuit which makes the correct connections for the valve,



CIRCUIT OF THE SECOND UNIT WHICH CONTAINS THE TEST SOCKETS

$R_1 = 100k.$
$R_2 = 50k.$
$R_3 = 25k.$
$R_4 = 1$ meg.
R_5, $R_6 = 20\omega$.
C_1, C_2, $C_3 = 0.5$ μf.
$C_4 = 0.001$ μfd.
$C_5 = 0.25$ μfd.
$S_5 =$ Two-pole multi-position filament voltage selector.
$S_6 =$ On/Off noise test switch.
$S_3 =$ S.P.D.T. plate volts selector.
$S_4 =$ S.P. four-position screen volts selector.

we are now in a position to trace the wiring of both units in conjunction and to examine the arrangements that have been made to cater for directly and indirectly heated valves, and for triodes, pentodes, and battery tubes.

V_1 is the 1000 c/sec. oscillator. The frequency is controlled by C_1, C_2, R_2, and R_3, which are fixed. R_4 and R_5 in series control the strength of oscillation and therefore the oscillator output voltage. R_5 is brought out to the front panel and is used on the Cal. position of the Cal./Test switch, S_{2a} and S_{2b}, which are ganged. It is adjusted until the eye tube, V_3, is just closed. R_7 and R_8 form the signal voltage divider which gives exactly half the oscillator output voltage for the calibration. The indicator circuit comprises V_2 and V_3. The former is a 6SN7, the first half of which is used as a resistance-coupled amplifier. The second half, V_{2b}, is connected as a diode and rectifies the output of V_{2a}. The filter, $R_{13}C_8$, removes the audio components from the rectifier output and applies the resulting D.C. signal to the grid of V_3, which is a 6E5. There is no gain control in the grid of the amplifier tube, so that the oscillator output needs to be only very small to close the eye. This ensures that the signal voltage applied to the valve under test is also very small—a necessary precaution, because the valve under test must not be worked outside its linear range, which is quite small, particularly in high-gm tubes, on account of the low value of cathode resistor then employed.

The oscillator output to the second unit is taken from the cathode of the oscillator tube. The lead goes to pin No. 1 on the output socket. Tracing its destination on the second unit, it goes first of all to the Noise Test switch, which is normally closed. Then comes a blocking condenser, C_4, and the grid leak, R_4, of the tube under test. The lower end of this resistor is bypassed to earth, and the output of the blocking condenser is taken to the banana socket marked Grid, whence it is connected to the tube under test. The lower end of the grid resistor is returned to pin No. 4 on the connector socket. From pin No. 4 on the connector socket in the first unit is connected an audio filter, C_7R_{16}, which in turn takes the grid return to the potentiometer, R_{15}. The latter is connected across the battery (18v.) which supplies the bias for the valve. The positive terminal of the battery is connected to pin No. 5 of the connector socket, as can be seen by tracing the connection from pin No. 5 on the second chassis connector socket to the cathode banana socket. Thus, the grid-cathode circuit of the valve under test is completed, and the bias is inserted exactly as in the schematic, Fig. 1. The switch, S_{1b}, is part of the On/Off switch, and breaks the battery connection when the instrument is not in use, preventing it from discharging. R_{18}, of course, is the calibrated resistor whose dial is marked directly in ma./v. The purpose of R_{17} is to make the scale a little more open at the high-gm end. Its value of 50 ohms gives the tester a maximum

(Continued on page 48.)

A Practical Beginners' Course

PART 25

In the last instalment of this course we started to learn a little more about valves, and, in particular, about their important properties—namely, Mutual Conductance and Amplification Factor. We learned that these properties have numerical values, by means of which one valve can be compared with another, and which can also be used when circuits are being designed, in order to calculate in advance what the performance of the circuit will be. For instance, it is quite an easy matter to estimate how much amplification can be obtained from a valve in a particular type of circuit if we know the amplification factor of the valve, in addition to the values of the resistors or the characteristics of the transformer that is used with the valve. Similarly, in R.F. amplifier stages, the mutual conductance is a very useful figure, because it enables the stage gain to be estimated in advance if the circuit conditions are also known. However, these things hardly come within the scope of the "beginner," although it is most necessary for him to know what the valve constants are, if only to enable him to read the radio literature intelligently and to understand the information given in the valve data books.

VALVE CURVES AND WHAT THEY MEAN

With regard to the latter, which are a veritable mine of information when properly used, it is essential for the user to be able to use the many curves that are invariably given as being the most compact method of presenting the greatest possible amount of information in the smallest possible space. These curves enable the best operating conditions to be found for the valve for any particular type of service, and also make it possible to calculate the amplification factor and mutual conductance for operating conditions other than those for which these factors are specifically stated in the tabulated data. Anyone who is really interested in how their valves work, and not only in building radio gear to someone else's design, but in designing their own equipment as well, must know how to interpret these curves. If he cannot, he is limited in the work done to using valves under the conditions listed in the book; these conditions, while they cover a great number of cases met with in practice, are no more than they pretend to be—namely, Typical Operating Conditions. The result is that, while there are innumerable changes that can be made to suit particular problems, only one who can interpret the valve curves is able to make workable changes from the typical conditions listed.

If two things are related to each other in some way, perhaps the easiest way of describing the relationship is by drawing a graph which shows how one of the things varies when the other is altered. Take, for instance, a valve whose plate voltage is fixed. The other two operating quantities are the plate current and the grid voltage. In other words, if the plate voltage is fixed, we can vary the grid voltage, which will cause the plate **current** to vary. For every value of grid voltage there is a corresponding plate current that will flow. It is therefore possible to describe the behaviour of the valve completely **for the given plate voltage** by drawing a curve which shows how the plate current varies with variations of grid bias. Fig. 33 shows such a curve. It is interesting to know that the grid volts–plate current curve for all values is similar in appearance to this one.

There are several points about the curve of Fig. 33 that are worth noting. First of all, the portion of the curve that applies to grid voltages between zero and some negative value (not specified on Fig. 33) is almost a straight line. That is to say, in this region, equal changes of grid voltage cause equal changes of plate current. This is most important, because it is only when this is true that the valve is able to amplify without distorting the signal. We will have more to say about this in a later instalment, but even at this stage it is clear that the curves can give a very good indication of what will happen in a given circuit, for one of the things we are most interested in about amplifiers is the amount of distortion they cause. Now, on Fig. 33, negative grid volts are measured from the vertical line, to the left along the horizontal one, and if the graph were an actual curve for a particular valve, the horizontal line would be marked off in volts, from right to left. The zero volts mark would be exactly on the vertical line. Similarly, the plate current would be marked in milliamps along the vertical line, from the bottom up, with the zero level with the horizontal line. The vertical and horizontal lines are called the **axes** of the graph, and where they cut is called the **origin.** All lines drawn parallel to the vertical axis represent fixed grid voltages, while all lines parallel to the horizontal axis represent particular values of plate current. The axes, and the divisions on them, do not depend at all on the curve that is drawn or upon the valve whose curve is to be drawn. It is the curve itself which contains all the information. For example, when the grid voltage has a value represented by the vertical dotted line (1), the plate current is given by the point where this line cuts the curve. The value of plate current may be read from the curve by drawing a horizontal line from which the exact value can be read. These are shown on the figure as three pairs of dotted lines, each of which shows the values of plate current and grid voltage corresponding to one point on the curve. With the aid of a graph of this nature, it is possible to answer a number of questions. For instance, "What grid bias has to be applied to the valve for the plate current to be 10 ma.?" To answer this one, all we have to do is to find the horizontal line representing 10 ma., travel along it until we hit the curve, and then travel vertically until the horizontal axis is met. The point at which this occurs gives us the answer in volts. If, on the other hand, we are given a particular grid voltage and want to find out what plate current will flow if this grid voltage is applied to the valve, the procedure is reversed. We start by finding the vertical line corresponding to the required bias, then travel vertically to meet the curve, and then from the point of intersection we go horizontally until we meet the vertical axis, where the plate current is read off.

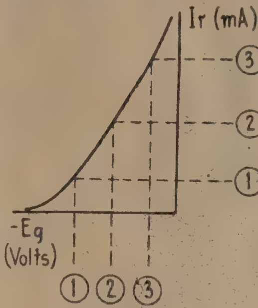


Fig. 33

These are examples of single readings being taken from the curve, but there are other answers that can be got by taking two or more readings. For example, if we want to know whether, when the grid bias is fixed at a certain figure, the greatest available signal will overload the grid circuit of the valve and produce distortion, this can be done by using the scheme outlined to find the plate current (a) without signal, and therefore when the grid voltage is equal to the grid bias, (b) with a grid voltage equal to the bias plus the peak A.C. signal voltage, and (c) with a grid voltage equal to the bias **minus** the peak signal voltage. If Fig. 33 is examined, it will be seen that if the "curve" is a straight line, but not otherwise, the difference between the no-signal plate current and the maximum plate current will be equal to the difference between the no-signal plate current and the minimum plate current. If there is any curvature in the "curve," these plate current differences will not be equal, and distortion is indicated. It is even possible to estimate the amount of such distortion in some cases through the use of a simple formula. Fig. 33 is drawn to illustrate an actual valve, which in practice never has an exactly straight-line curve.

At high negative grid voltages the curvature becomes more pronounced, and finally is quite flattened off, from which it can be seen that if the grid bias is too high, the valve will produce a very distorted output when handling a signal. The three sets of dotted lines serve to illustrate the action of the valve when an A.C. signal is applied to the grid. Since the signal going in is assumed to have positive and negative peaks of the same size, if we regard (2) as the fixed bias voltage, then the positive peak of the signal is represented by the grid voltage and plate current labelled (3). Similarly, the plate current and grid voltage represent conditions at the negative signal peak. Now, supposing the signal has a peak value of 2 volts, then the distance along the grid-voltage axis represented by (2) to (1) is two volts. Similarly, (2) to (3) represents the positive signal swing of two volts. Now, although these grid voltage changes on each side of the bias voltage are equal in size, it can be seen from the figure that the corresponding plate current changes are not equal, because of the curvature of the valve curve. Thus, the output signal, which is got from the plate circuit, does not have the same positive and negative peak sizes, whereas the input signal has. This is a practical demonstration of how distortion arises.

ESTIMATION OF MUTUAL CONDUCTANCE FROM THE CURVE

Another use for the curve of grid volts against plate current is in finding the mutual conductance of the valve if this figure is not quoted in the data book, or if a figure is required for conditions other than those for which the mutual conductance is given. Suppose that the change of bias in going from position (2) on Fig. 33 to position (3) is exactly one volt and that the plate current (2) is 4 ma. and the plate current (3) is 6.5 ma. In this case, a change of grid bias of one volt causes a plate current change of 2.5 ma. The plate current change is therefore 2.5 ma. for each volt of grid-voltage change, or, in other words, 2.5 ma. per volt, and this is the mutual conductance of the valve between points (2) and (3) on the curve. Commercial valve-testers use the same principle for actually measuring the mutual conductance of the valve. Here the grid voltage is actually changed by one volt, and the change in plate current is read on a meter, thus giving the required answer, directly in milliamps per volt.

In the whole of this discussion, we have assumed that the plate voltage was fixed. However, it is possible to vary this as well as the grid voltage, so that the question crops up, "How does the curve given in Fig. 33 make allowance for changes in plate voltage?" The answer is that it does not. In other words, a single curve is not all that we need to display the operation of the valve under any conditions of plate voltage and grid voltage. The single curve of Fig. 33 tells us what happens under any conditions of grid voltage **only for one particular plate voltage.**

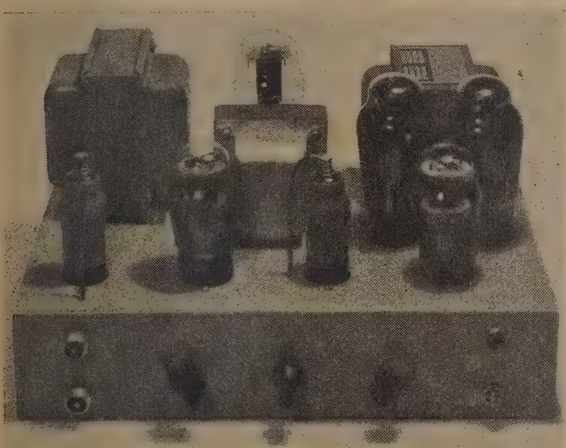
(To be continued.)

The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of New Zealand.

No. 11: A HIGH-FIDELITY AMPLIFIER USING EL37's AS TRIODES

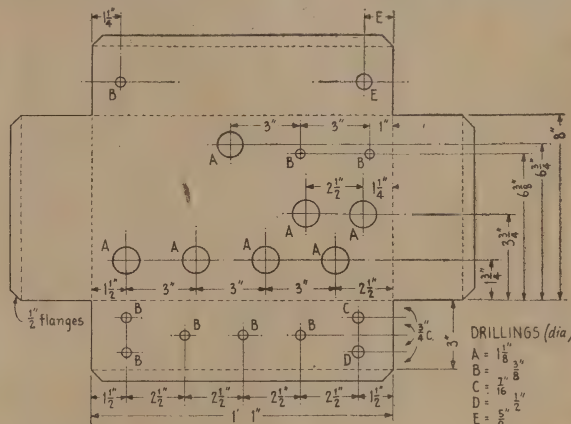
This month's Experimenter represents something of a departure from the types of equipment that have been described, in that this time we are addressing ourselves not only to amateur transmitters, but also to all those who may have a requirement for an amplifier in the really high-quality class. Although the amplifier comes within this class, it is by no means as expensive to build as many designs that aim at similar results. In fact, the only item which requires any more than the usual amount of capital outlay is the output transformer. Resistance-capacity coupling is used throughout, provision is made for using a gramophone pick-up or a low-level microphone, or both simultaneously, by means of a mixing circuit, and exceedingly low distortion is realized by the now well-known expedient of using triodes in the output stage, with a large degree of negative feedback. The circuit calls for six valves and a rectifier.



General view of the amplifier.

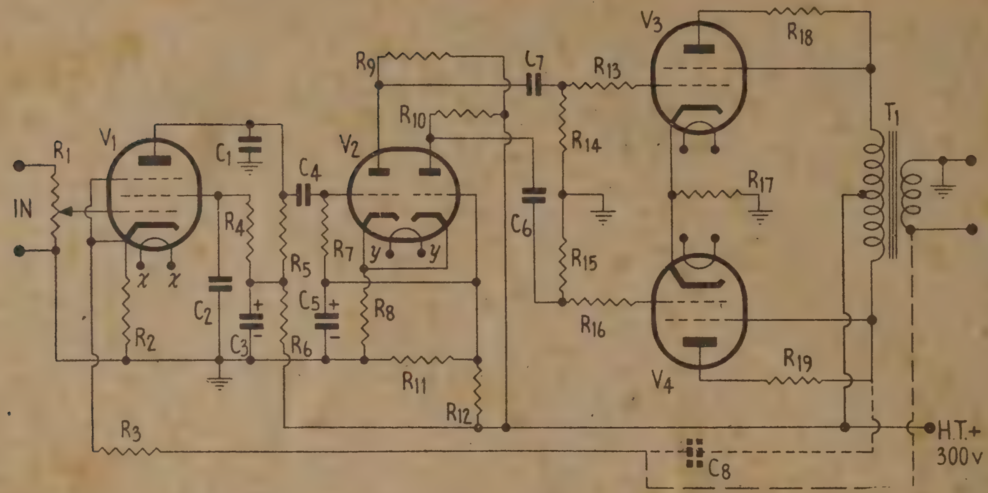
VALVE LINE-UP AND OTHER CONSIDERATIONS

In choosing an array of valves for this amplifier, it was decided to make use of the EL37, triode-connected, rather than to use one of the larger power triodes. There are a number of reasons for this. First of all, the residual hum can be reduced to a very low level by means of indirectly-heated output tubes, without having to take elaborate precautions. Secondly, the power supply is simplified, because the output valves can be supplied with heater voltage from the same winding as the rest of the amplifier. More important than this is the fact that the triode-connected EL37 has a much higher mutual conductance and amplification factor than any triode of comparable plate dissipation. This gives the output stage greater power sensitivity, which in turn makes it easier for the voltage amplifier stages to deliver the required grid-driving voltage with low distortion. In practice, this means that the EL37 needs only 23 volts peak signal when the plate voltage is 300, or 36 volts peak when the plate voltage is 400, to swing it to full output. Large power triodes capable of approximately the same power output usually need from 50 to 100 volts peak for the same output. The advantage of the EL37's is therefore considerable, in that it is much easier to get an undistorted output of 23 to 36 volts peak from the resistance-coupled driver stage than it is to get from 50 to 100. In fact, the latter is wellnigh impossible to attain unless very high H.T. voltages are used for the voltage amplifier stages, or unless special circuits are resorted to. The use of the EL37, therefore, enables the voltage amplifiers to be run at a lower output level, at which their contribution to the overall distortion is smaller than when they are called upon to deliver something like their maximum output voltage. It should be emphasized that such reduction in distortion means that the total distortion **without** feedback is less, so that when feedback is applied, the total is still lower than if such precautions had not been taken. In other words, the fact that a large amount of feedback is used should not be regarded as an easy way of compensating for poor design. An amplifier should be designed for minimum distortion before the feedback connection is thought of, after which the feedback produces the greatest possible benefit.



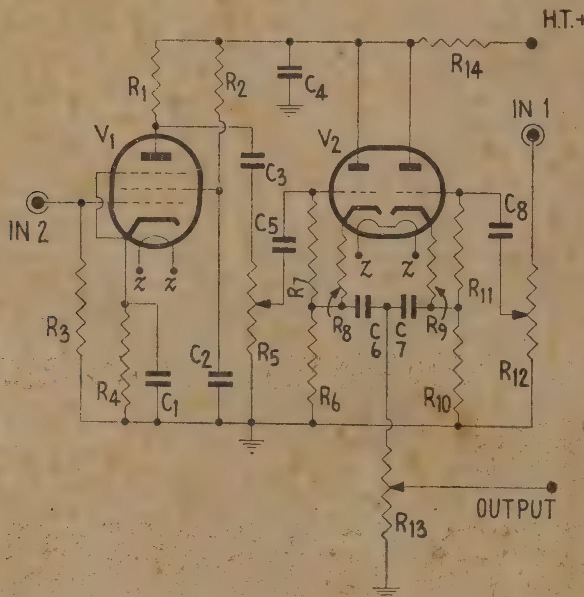
Working drawing for the amplifier chassis.

The phase-reversal stage makes use of the ECC32 double triode. This is an excellent valve for the purpose, having an amplification factor of 32 in each section and the comparatively low plate resistance of 14,000 ohms per section. The circuit used is the cathode-coupled one, in which the signal developed across a large cathode resistor, common to both sec-



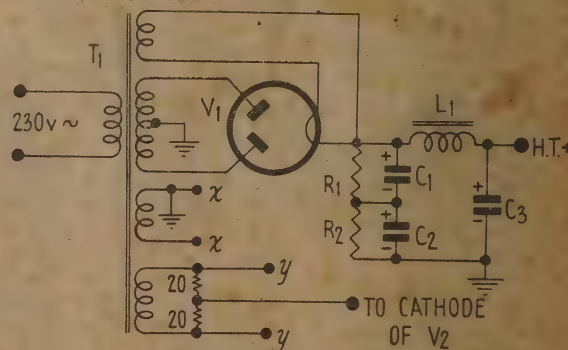
At Left: Main amplifier circuit, with parts list directly underneath.

V_1, EF37. V_2, ECC32.
R_1, 0.5 meg. pot. V_3, V_4, EL37.
R_2, 1500 ohms.
R_3, R_5, R_9, R_{12}, R_{13}, R_{16}, 100k.
R_4, R_7, 250k.
R_8, 20k. R_6, 50k.
R_{10}, 120k. R_{11}, 12.5k.
R_{14}, R_{15}, 500k.
R_{17}, 250 ohms, 2 watts.
R_{18}, R_{19}, 50 ohms.
C_1, 100 mmfd. (necessary only if H.F. instability occurs).
C_2, 0.5 mfd.
C_3, C_5, 8 mfd. 450v. electro.
C_4, C_6, C_7, 0.1 mfd.
C_8 (if used), 4 mfd. 500v. oil-filled.
T_1 (see text), 7000 ohms to voice-coil.



Above, pre-amplifier and mixer.

R_1, R_{14}, 100k.
R_2, 250k.
R_3, R_7, R_{11}, 1 meg.
R_4, 1000 ohms.
R_5, R_{12}, R_{13}, 500k. pot.
R_6, R_{10}, 50k.
R_8, R_9, 1500 ohms.
C_1, 50 mfd. 25v. electro.
C_2, C_8, C_7, 0.5 mfd.
C_3, 0.004 mfd.
C_4, 8 mfd. 450v. electro.
C_5, C_8, 0.05 mfd.
V_1, EF37.
V_2, ECC32.



Suggested power supply circuit.

T_1, 385–0–385v., 150 ma., 6.3v., 4 amps., 6.3v., 2 amps., 5v., 3 amps.
L_1, 20–30 H., 150 ma. (With the standard transformer specified, enough resistance should be placed in series with L_1 to drop the filter output voltage to 330v. If a transformer with a lower secondary voltage is available, this resistance will not be necessary.)
C_1, C_2, C_3, 16 mfd. 450v. electro. V_1, 83, or 83v.
R_1, R_2, 1 meg. equalizing resistors.

Note on Heater Connections.—All heaters marked x and the EL37 heaters should be run off the winding similarly marked. Those of the two ECC32's, marked y and z, should be run from the other heater winding, marked y.

tions, is used to excite the out-of-phase section (ie., the one whose grid is grounded as far as signal is concerned). The grid returns of both sections are taken to a point of positive potential, which offsets the high negative bias that would be caused by the large cathode resistor alone. This places a potential difference of about 32 volts between the heater and

OUR GOSSIP COLUMN

Ralph Slade recently returned from a two-weeks business visit to Auckland. Asked how he survived the Queen City weather, Ralph replied that he was too busy to notice the weather, but remembers a warm reception at Geo. Wooller's birthday party, at which the usual Auckland hospitality flowed freely.

* * *

J. Blackie, of Photo-Engravers, Auckland, spent a social half-hour after 5 p.m. with Stan Shea. Incidentally, Joe, does Peter McIntyre's sketch flatter you?

* * *

Joe Bennett, of Radio Centre, Christchurch, popped in to see us recently. His special problems were revised race days and sales. According to Joe, there should be all sales and no races!

* * *

Mr. A. J. Wyness, Director of His Master's Voice (N.Z.), Ltd., recently returned from Australia after he had been arranging for record-pressing machines to be imported from Britain. It is hoped that by early next year, recordings by New Zealand singers will be made for the retail market.

* * *

Mr. S. Cory-Wright, Managing Director of Messrs. Cory-Wright and Salmon, well known for his active interest in the radio and electrical fields, is also a keen worker for the Federal Union for World Government Movement in New Zealand, an organization whose aim is to educate public opinion and so foster the objectives of peace through the United Nations. Much organizing work was carried out in this field by Mr. Cory-Wright during the recent visit to New Zealand of Lord Beveridge, one of the world's prominent advocates of this movement.

* * *

Radio Patents:

Considerable interest is centred on the Patents Commission at present receiving evidence. It has been suggested by the Department of Industries and Commerce that the existing law should be amended to allow a tribunal to deal with attempted breaches of patent rights and attempts by patent-holders to impose excessive royalties and restrictive trade conditions. The main argument in favour of such a tribunal is that it would offset the high cost of the usual method of patent litigation which is often very prolonged and not always decisive.

THE "R. & E." PORTABLE COMPETITION

Our sincerest apologies are due to Messrs. Webb's Radios Ltd. of Auckland for the omission of their name as one of the prize donors in the above competition. Their contribution is to increase the prize list to include sixth and seventh prizes, each of £2/10/- worth of radio components. The total prize list therefore adds up to £50 value in radio components of which the first prize comprises goods to the value of £25, and in which none of the prizes is worth less than £2/10/-. Those who have not seen the details of the competition should refer to pages 4 and 5 of the September, 1948, issue, where full information is given. The closing date for entries is not till 15th October, so that intending competitors still have plenty of time in which to prepare their entries.

NEW PRODUCTS

LATEST RELEASES IN ELECTRONIC EQUIPMENT

Standard Telephones and Cables have the following instruments available for the radio serviceman or amateur who wishes to build his own service equipment:—

Weston Model 301 D.C. Microammeters, 0–50 microamps, resistance 1140 ohms.

Weston Model 301 D.C. Milliammeters, 0–1 milliamps, resistance 27 ohms.

Weston Model 301 D.C. Microammeters, 0–500 microamps, resistance 310 ohms.

These instruments are in rectangular cases and have knife-edge pointers, giving extremely accurate readings.

TRADE WINDS

A PHILIPS VALVE MANUAL

We are informed by Messrs. Philips Electrical Industries of New Zealand Ltd. that there will shortly be released the first copies of the Philips Valve Manual. This will be the first time that full ratings and operating data for Philips valves have been published in this country, and the Manual will no doubt be welcomed by all valve users.

The Manual will be in loose-leaf form, and the first issue will contain something over one hundred pages. Each valve type will be very fully treated, especially with respect to the graphic presentation of data. A charge will be made for the first issue, which will include the loose-leaf binder, and there will be a further annual charge for the issue at frequent intervals of additional leaves, covering valve types not included in the original issue. This annual charge also covers the supply to subscribers of Philips Application Notes, which will be uniform with the manual data sheets, and which will be sent out at the same time as the regular issue of these sheets. The Application Notes will be classified according to the valve types most prominently concerned in the subject matter of the notes, and will cover a wide variety of applications, ranging from what may be termed "Normal" applications, to some of the more abstruse and lesser-known types of valve circuit that are used in specialized equipment of various sorts. Those interested should apply direct to Philips Electrical Industries of N.Z., Ltd., Box 1673, Wellington.

A NEW DEVELOPMENT IN TAPE RECORDERS

The Brush Development Company, of America, who entered the field so successfully with the Soundmirror magnetic tape recorder have announced a new model of this machine for which outstanding advantages are claimed. The BK-416, as it is called, is a drive mechanism, complete with the recording and erasing heads, mounted on a panel which is easily incorporated in any cabinet. Great advances have been made in simplifying the operation of the unit, one lever now sufficing to control all movements previously controlled by a number of switches, dials and buttons. An improved system of tape threading has also been used, and provision has been made to prevent double recording and accidental erasure. The new recorder even rewinds itself, ready for playback, automatically at the end of its 30-minute spell of recording!

VALVE TESTER

(Continued from page 35.)

reading of 20 ma./v., which is quite high enough for most valves currently available! The open-circuit phone jack is for testing the valve for noise. The 1000 c/sec. audio output of the cathode follower appears across it, so that when the phones are plugged in, the signal can be heard. The Noise Test switch, S_6, on the second chassis, enables the signal input to be disconnected in order that noise in the valve may be heard in the absence of signal.

The H.T. arrangements appear somewhat complex, but in reality are quite simple. V_1, V_2, and V_3 have H.T. volts applied at all times. H.T. is taken to the second chassis via pin No. 6 on the connector socket. The power supply has a heavy bleeder, R_{20}, permanently across it, and a tap at 45v. is taken to pin No. 8 on the connector socket. Pin No. 7 on the socket carries a connection from S_3 on the second chassis. This switch is in series with S_{2b}, part of the Cal./Test switch. S_3 selects either the full H.T. voltage or the 45v. tapping on the bleeder for application to the valve under test, and the leads connected to pins Nos. 6, 7, and 8 of the connector have the sole purpose of enabling S_3 to be placed on the second chassis, with the other switches that need to be set before a reading has to be taken. S_{2b} is ganged with S_{2a}, and disconnects the H.T. to the tube being tested during setting up and calibration. This prevents accidents through H.T. being present on the wander-leads while the test circuit is being set up. The filter, $R_{10}C_9$ feeds the plate of the valve under test via the plate current meter and pin No. 2 on the connector socket. A separate lead, through pin No. 3 is taken to the second chassis, where it supplies the H.T. voltage for the screen dropping resistors. The separate lead is necessary because we do not want the screen current to flow through the plate current meter.

(To be continued.)

RESISTANCE-COUPLED AMPLIFIERS

(Continued from page 30.)

since the output voltage may be only a few volts, or even a fraction of a volt.

(2) **Omission of the Cathode Bypass Condenser.**—Doing this helps to keep the response flat at low frequencies, and somewhat reduces the stage gain. It may also reduce the high-frequency response if the cathode resistor has a high value.

"R. & E." ABSTRACT SERVICE

(Continued from page 32.)

output pulse of adjustable width without necessity for separate pulse generator.

—**Electronic Engineering** (Eng.), June, 1948, p. 196.

TV transmitter design. Description and circuits of exciter unit, video modulator unit, video-amplifier-modulator, and class B linear amplifier stages. Operation of diode D.C. restorers in video-amplifier-modulator analyzed and importance stressed.

—**Communications** (U.S.A.), May, 1948, p. 12.

TV transmitter design. Further study of D.C. restorer action, modulated amplifier operation, and more comprehensive details of class B linear amplifier.

—**Communications** (U.S.A.), June, 1948, p. 20.

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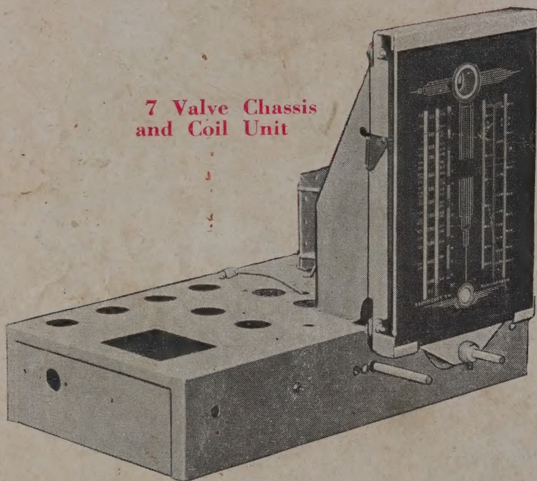

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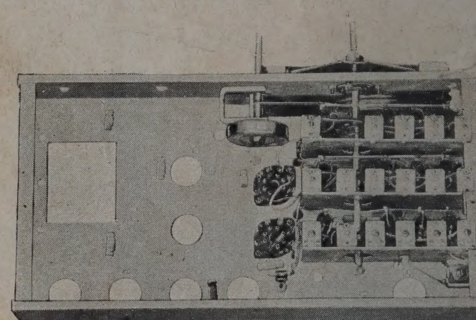

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